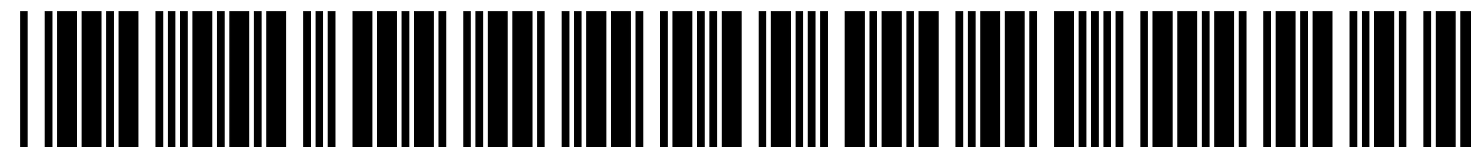
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Rice et al.

(10) **Patent No.: US 11,894,257 B2**
(45) **Date of Patent: Feb. 6, 2024**

(54) **SINGLE WAFER PROCESSING ENVIRONMENTS WITH SPATIAL SEPARATION**

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(73) Assignee: **Applied Materials, Inc.**, Santa Clara, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 768 days.

(21) Appl. No.: **16/171,785**

(22) Filed: **Oct. 26, 2018**

(65) **Prior Publication Data**

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Related U.S. Application Data

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(51) **Int. Cl.**
H01L 21/68 (2006.01)
H01L 21/687 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01L 21/68785*** (2013.01); ***C23C 16/4409*** (2013.01); ***C23C 16/4584*** (2013.01); ***C23C 16/45525*** (2013.01); ***C23C 16/46*** (2013.01); ***H01L 21/6719*** (2013.01); ***H01L 21/67103*** (2013.01); ***H01L 21/67248*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01L 21/68785; H01L 21/68764; H01L 21/68771
See application file for complete search history.

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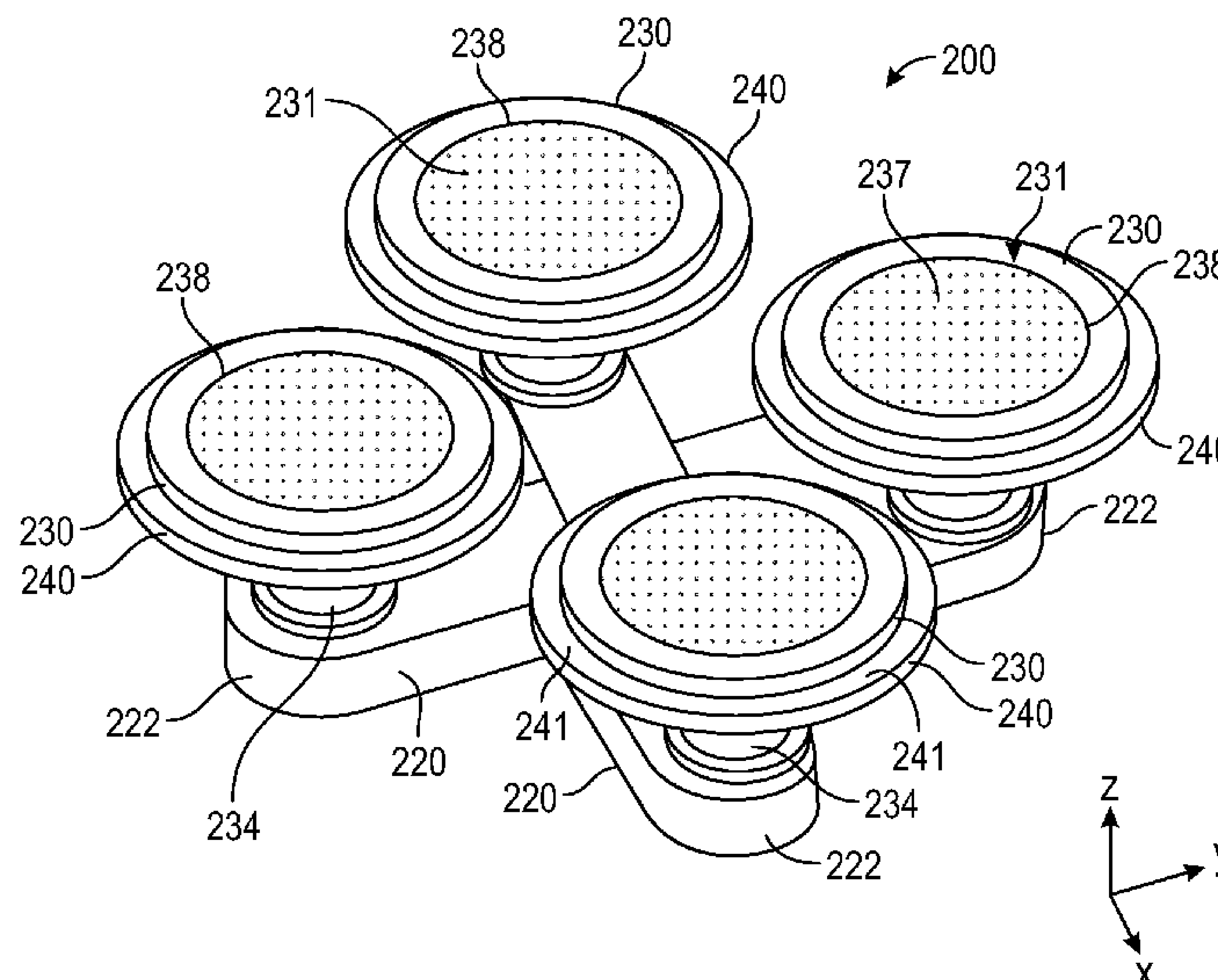
Primary Examiner — Keath T Chen
(74) *Attorney, Agent, or Firm* — Servilla Whitney LLC

(57) **ABSTRACT**

Apparatus and methods to process one or more wafers are described. A plurality of process stations are arranged in a circular configuration around a rotational axis. A support assembly with a rotatable center base defining a rotational axis, at least two support arms extending from the center base and heaters on each of the support arms is positioned adjacent the processing stations so that the heaters can be moved amongst the various process stations to perform one or more process condition.

17 Claims, 14 Drawing Sheets



(51) **Int. Cl.**

C23C 16/44	(2006.01)
C23C 16/458	(2006.01)
H01L 21/67	(2006.01)
C23C 16/46	(2006.01)
H01L 21/683	(2006.01)
C23C 16/455	(2006.01)

(52) **U.S. Cl.**
CPC ***H01L 21/6831*** (2013.01); ***H01L 21/6833*** (2013.01); ***H01L 21/68764*** (2013.01); ***H01L 21/68771*** (2013.01)

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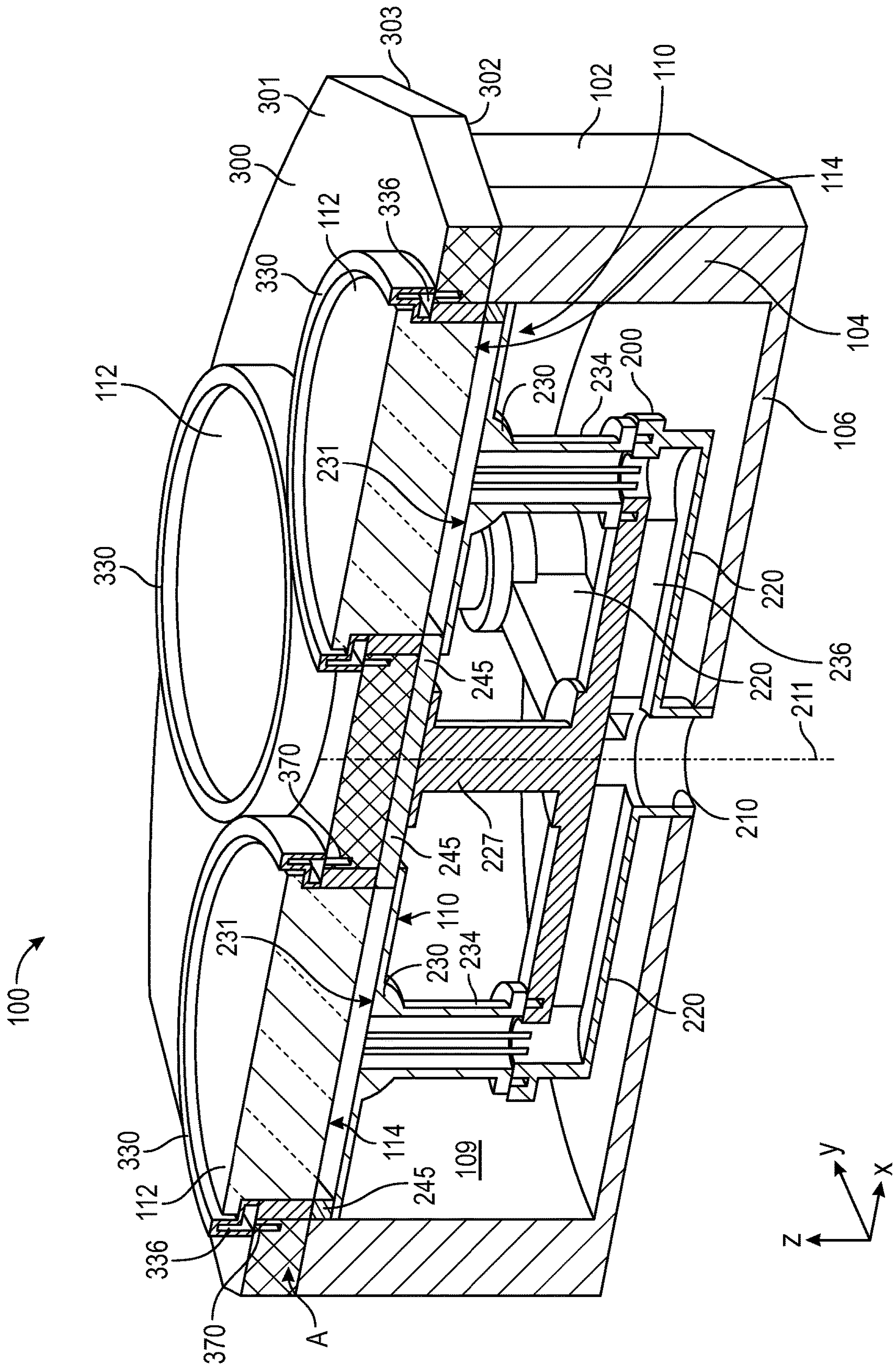

FIG. 1

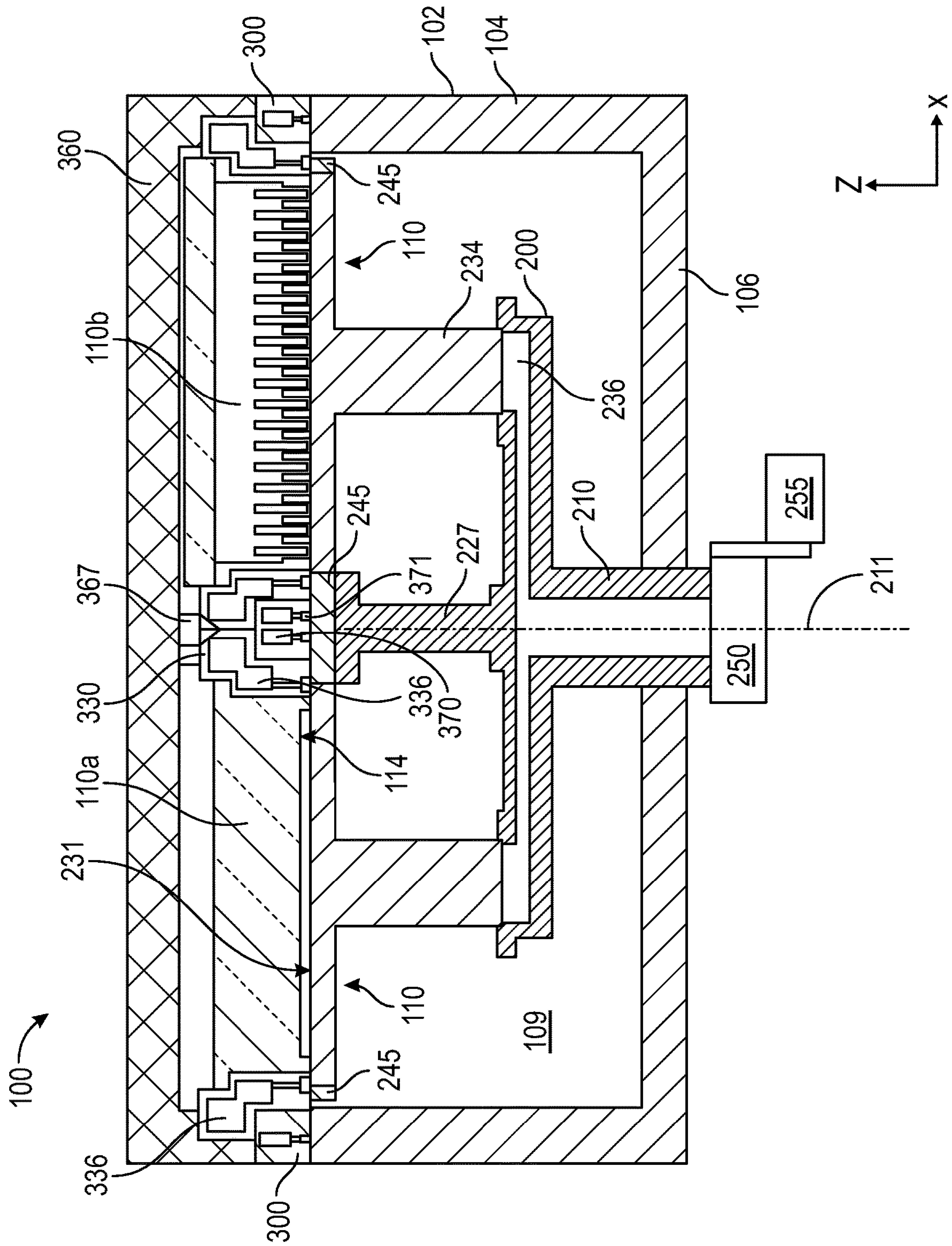

FIG. 2

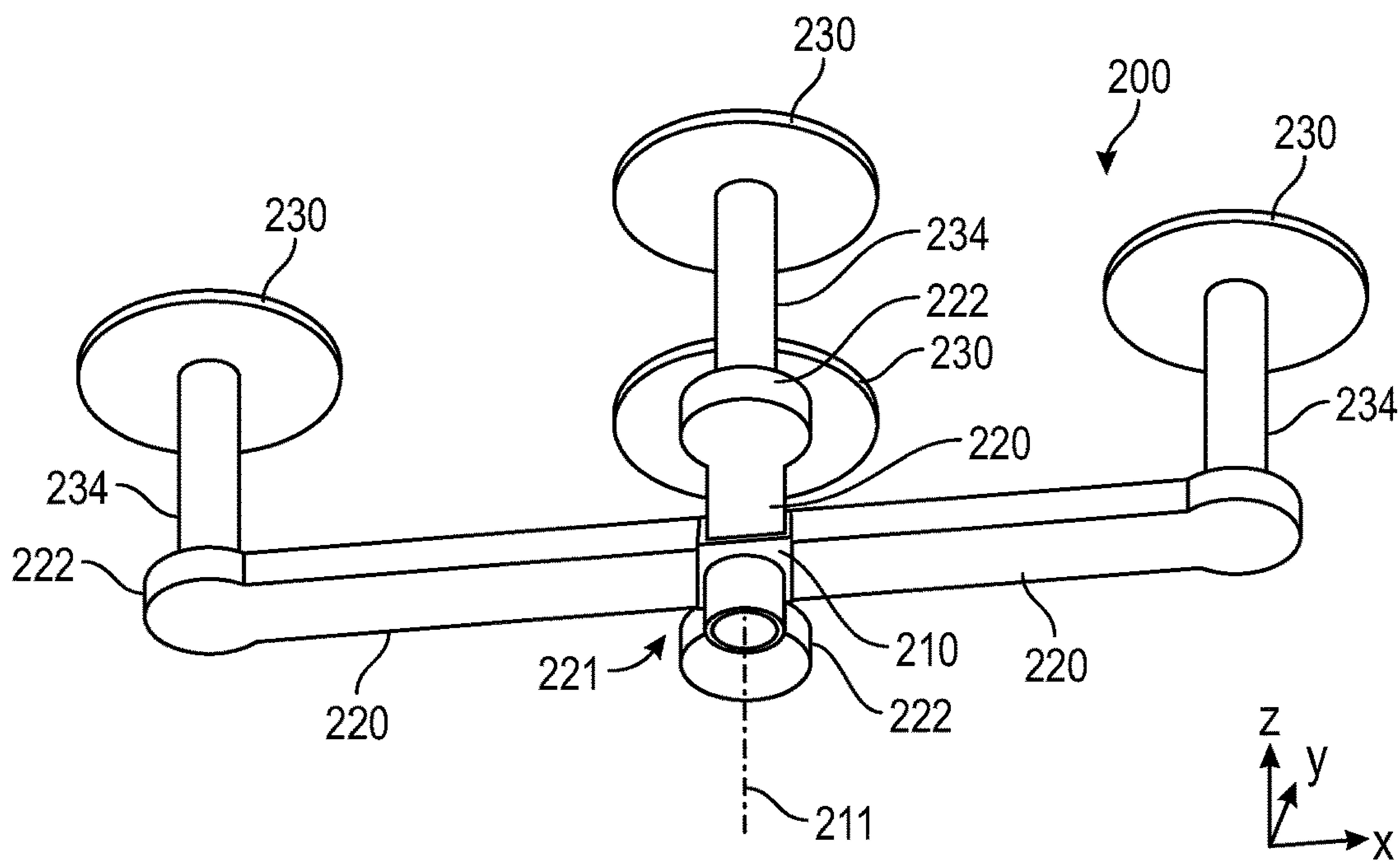

FIG. 3

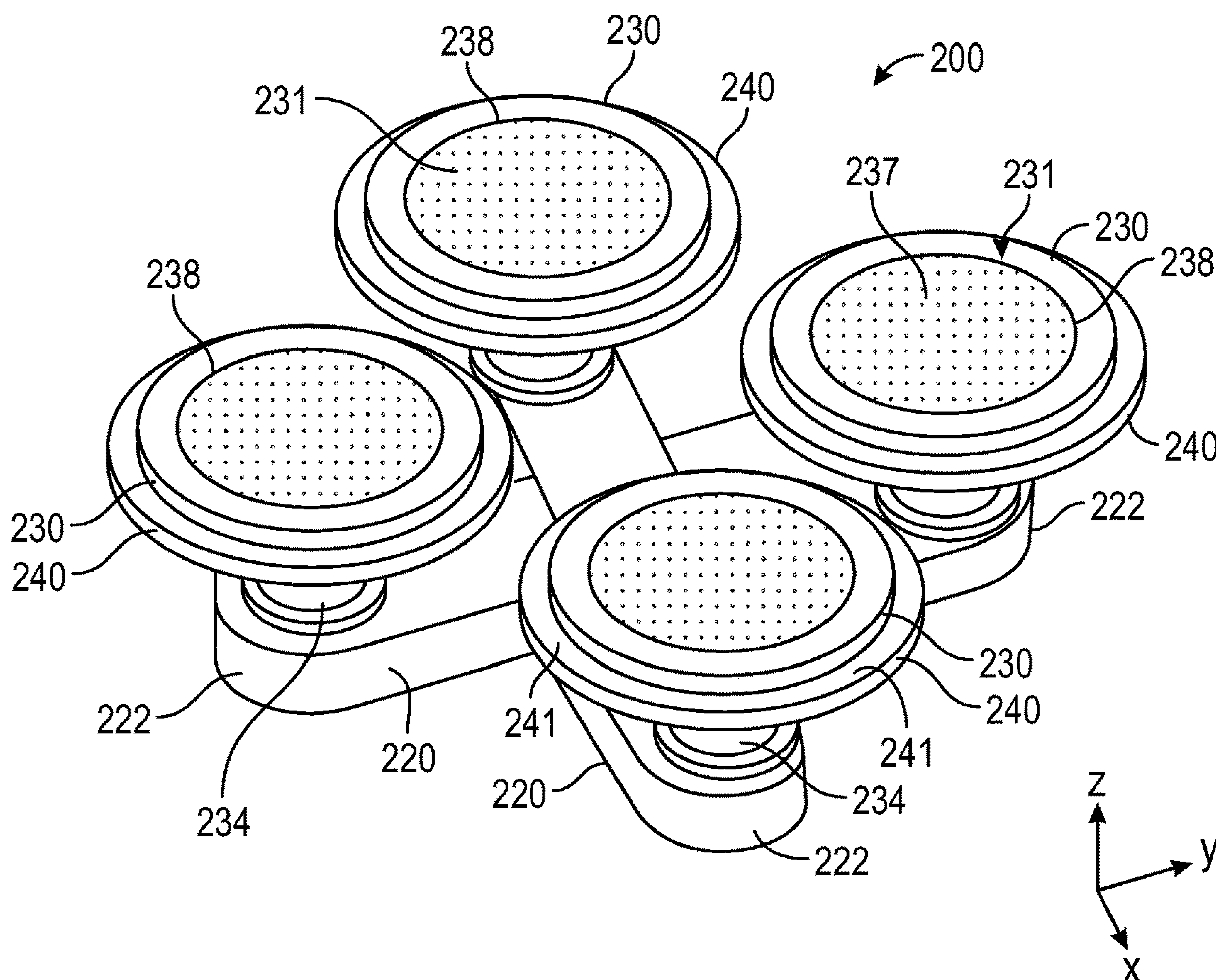

FIG. 4

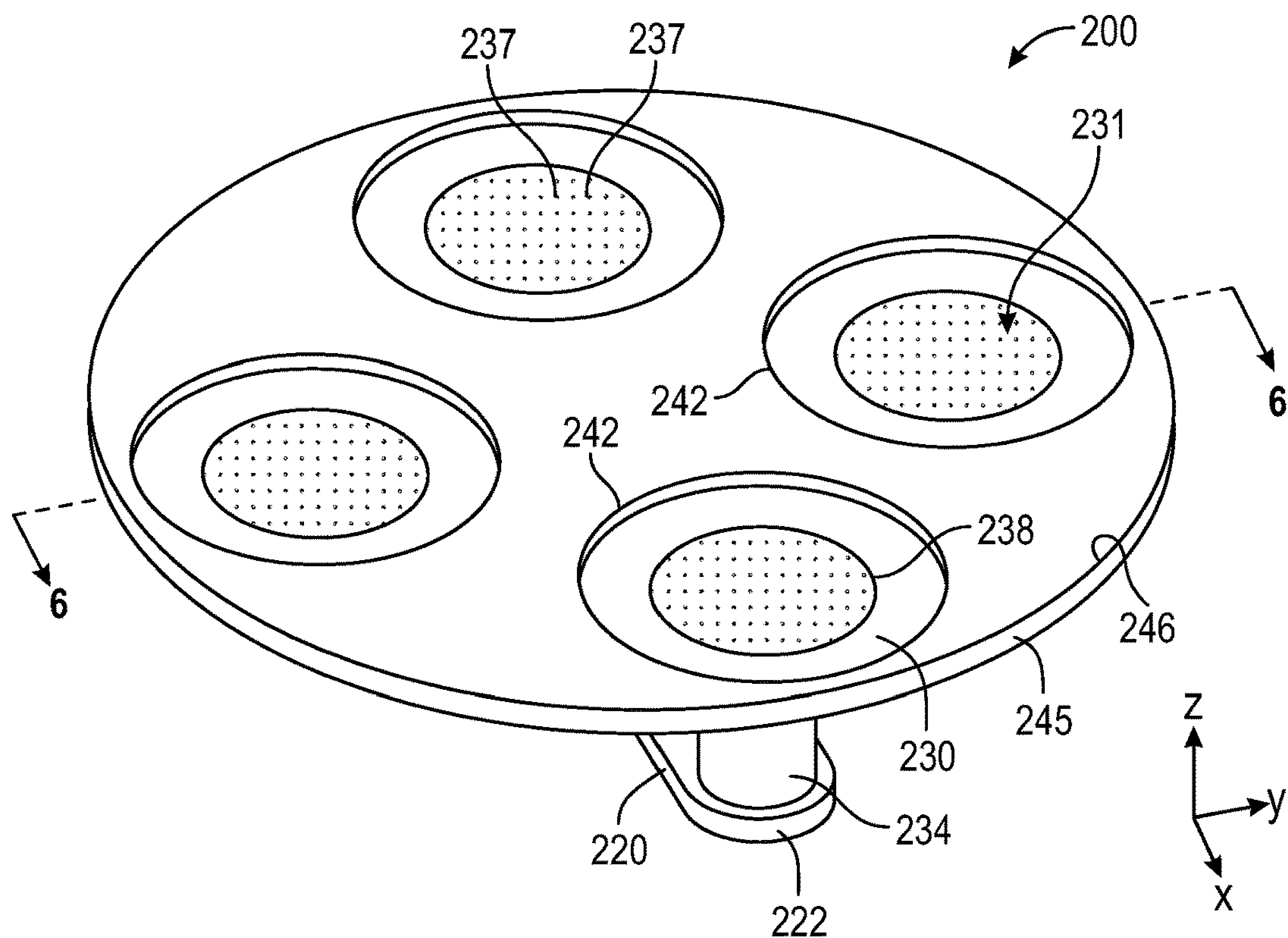

FIG. 5

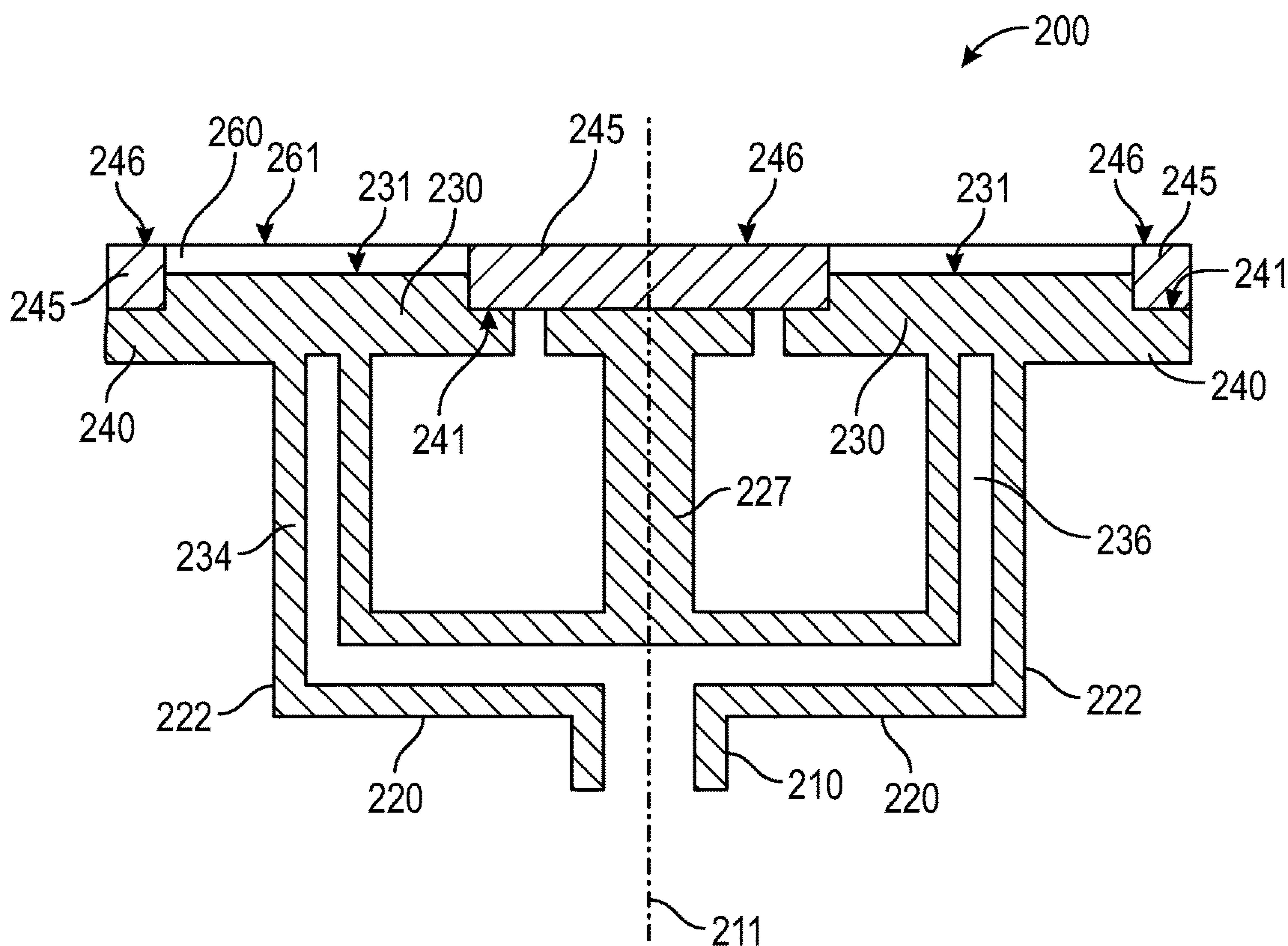

FIG. 6

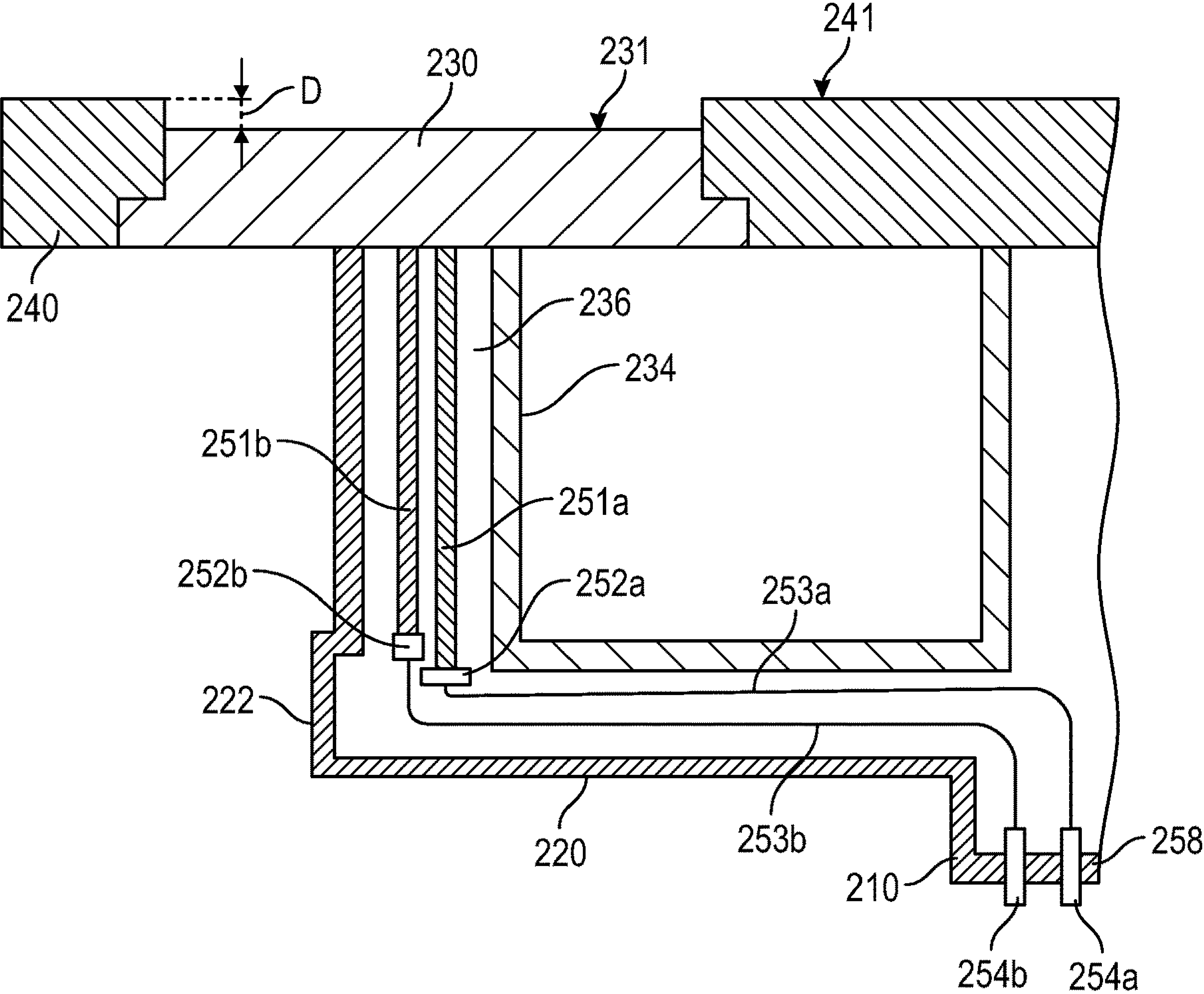

FIG. 7

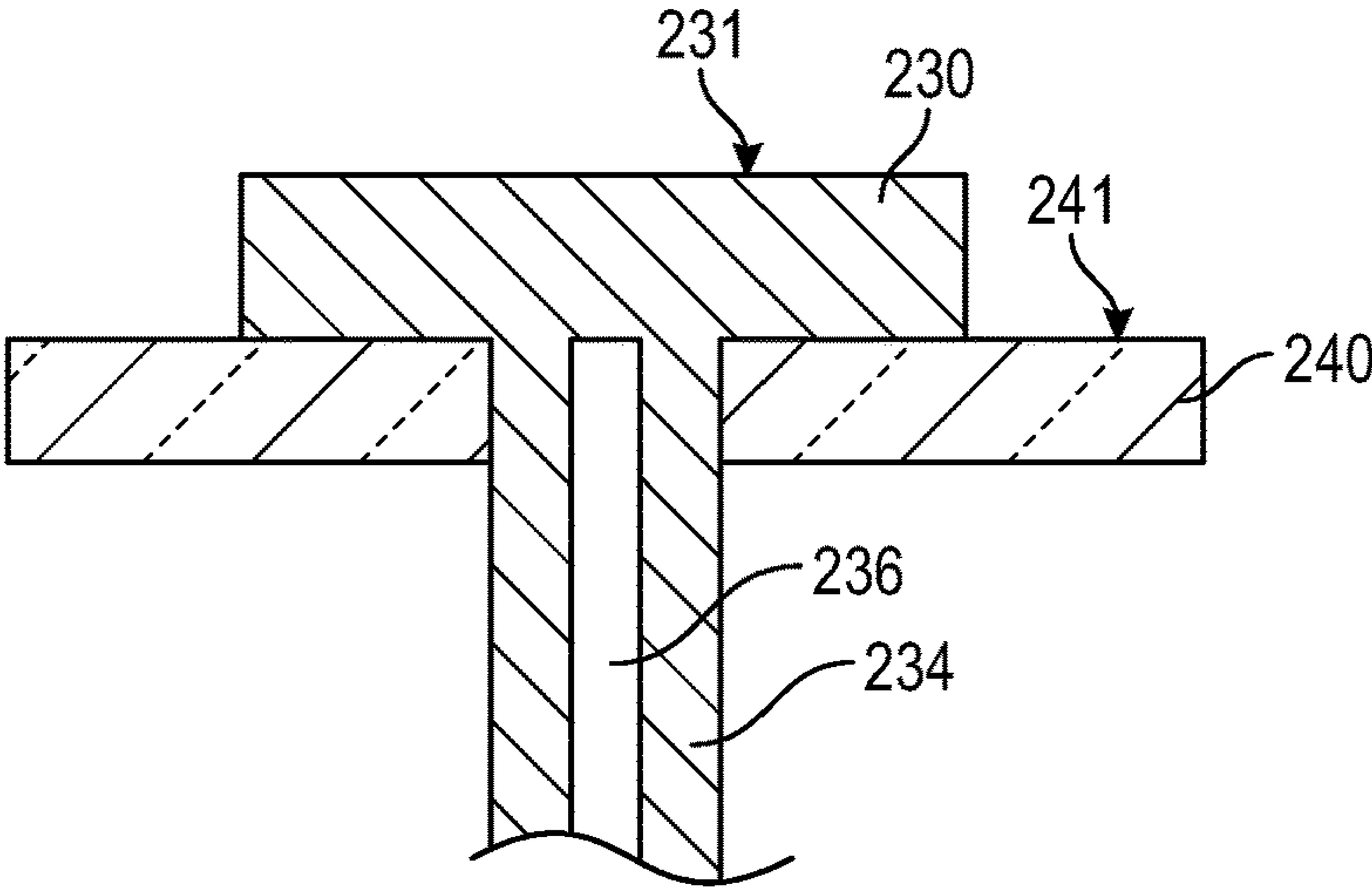

FIG. 8

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FIG. 9

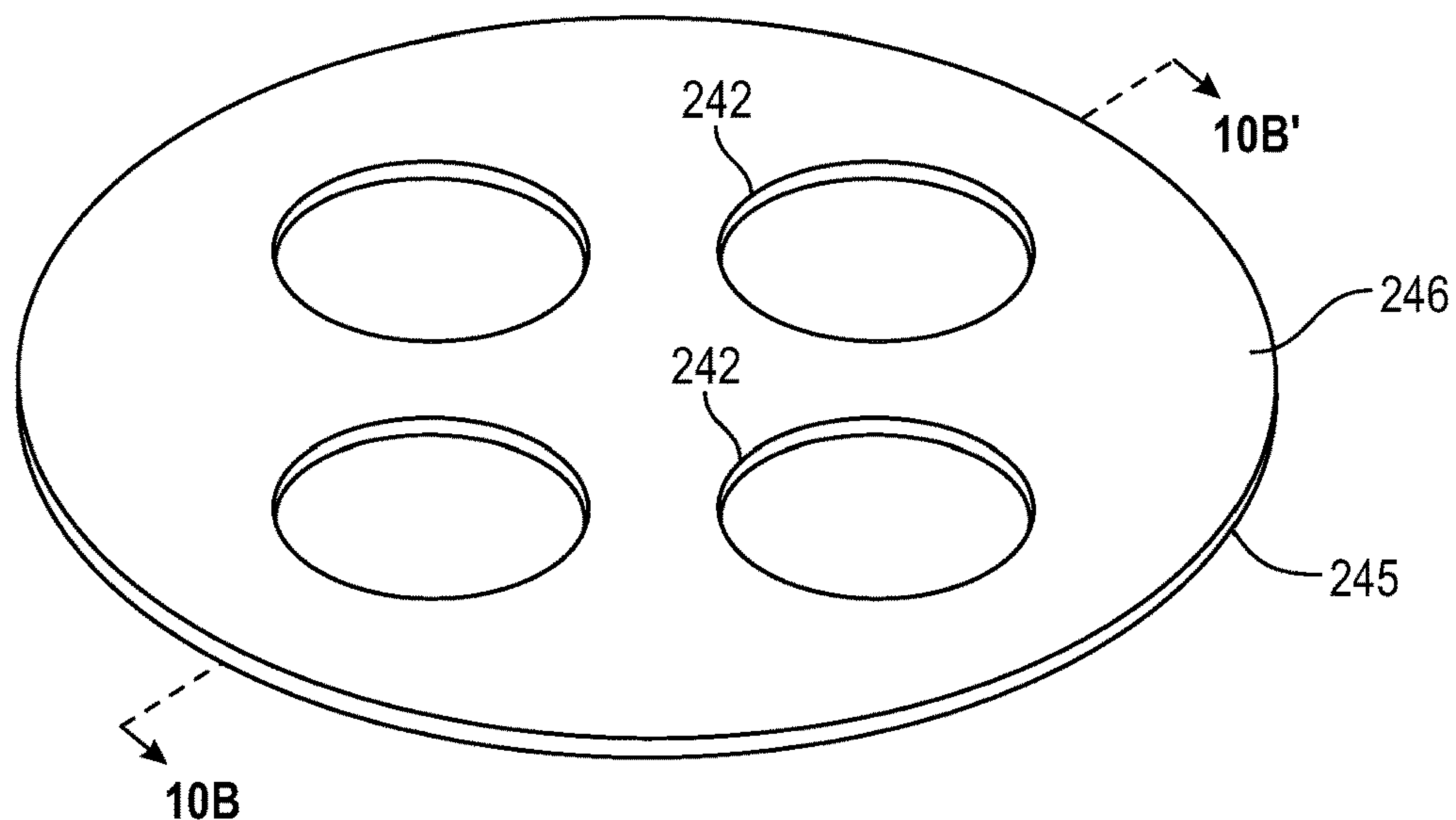

FIG. 10A

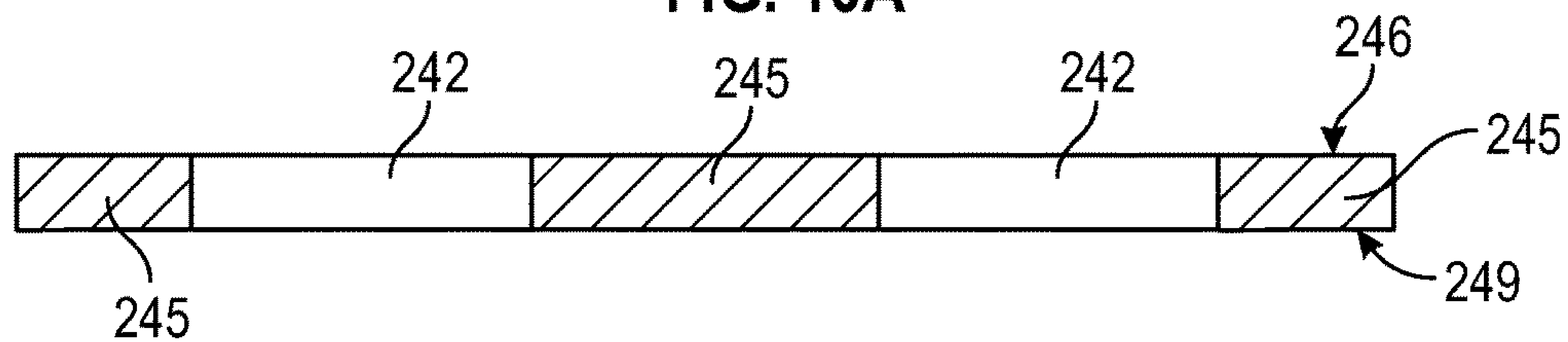

FIG. 10B

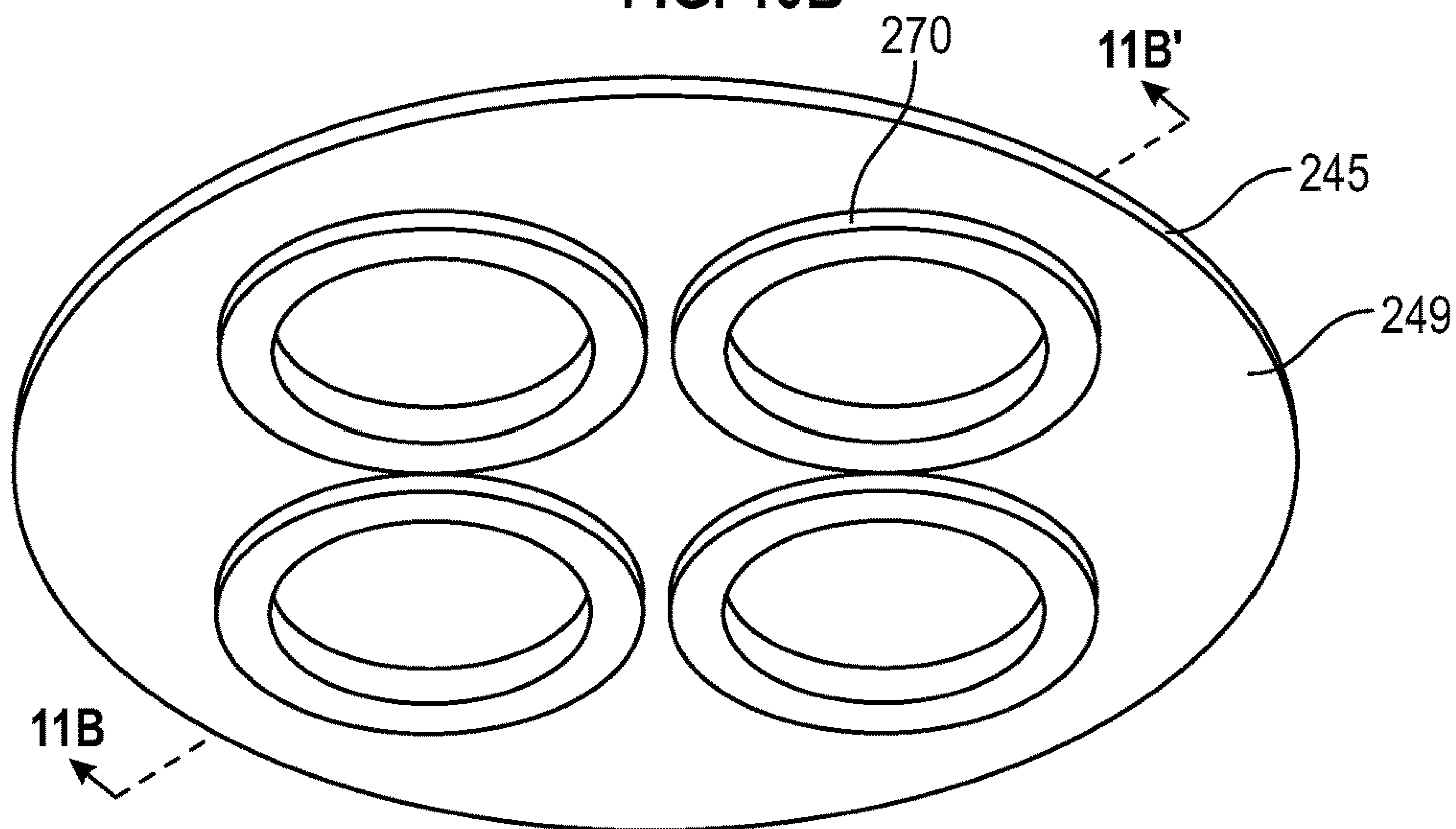

FIG. 11A

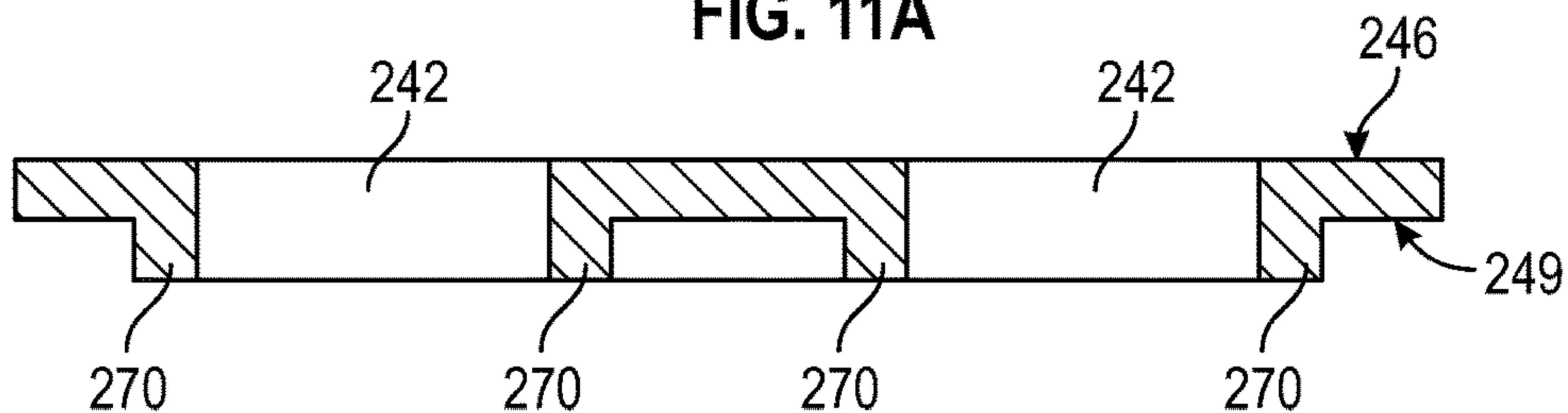

FIG. 11B

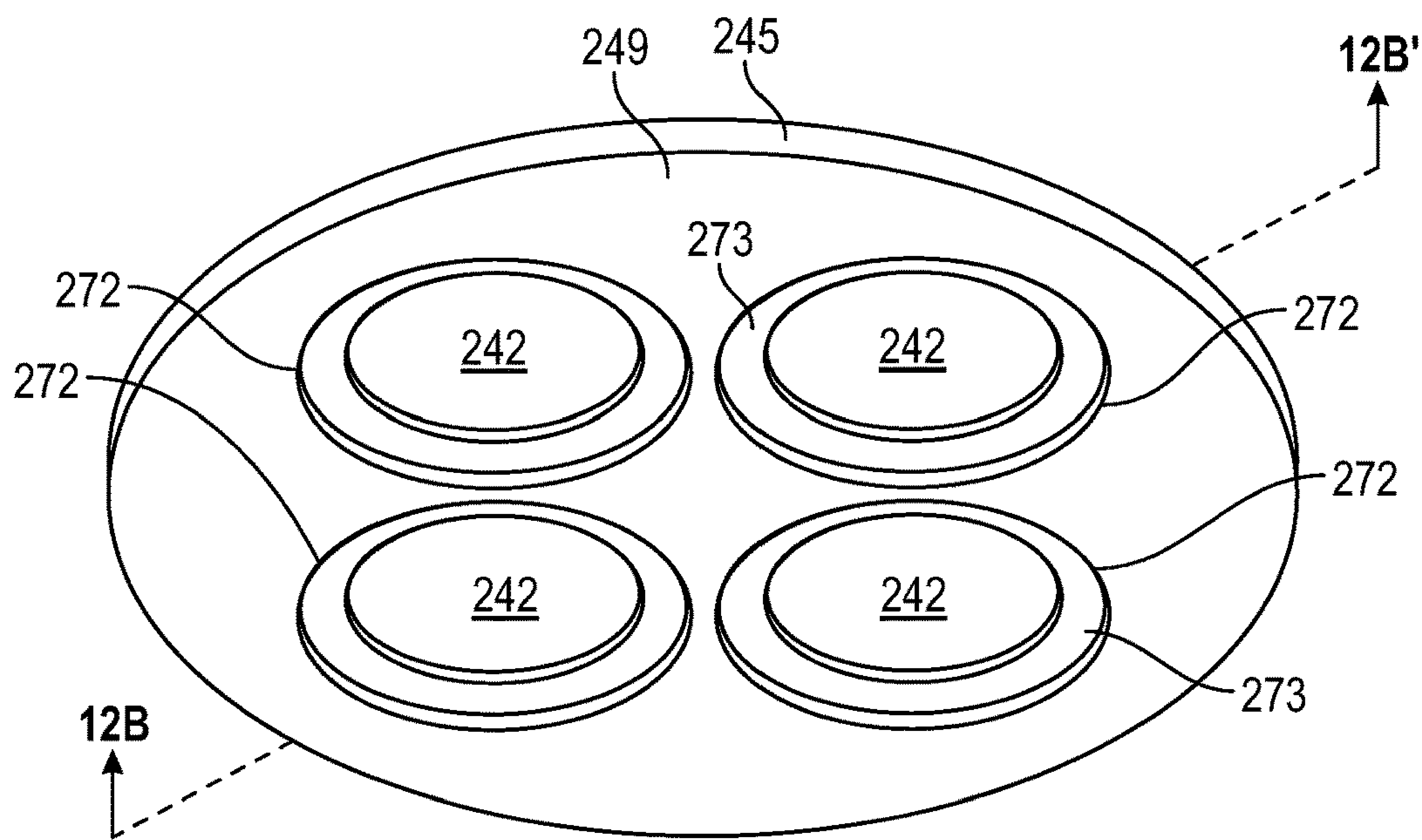

FIG. 12A

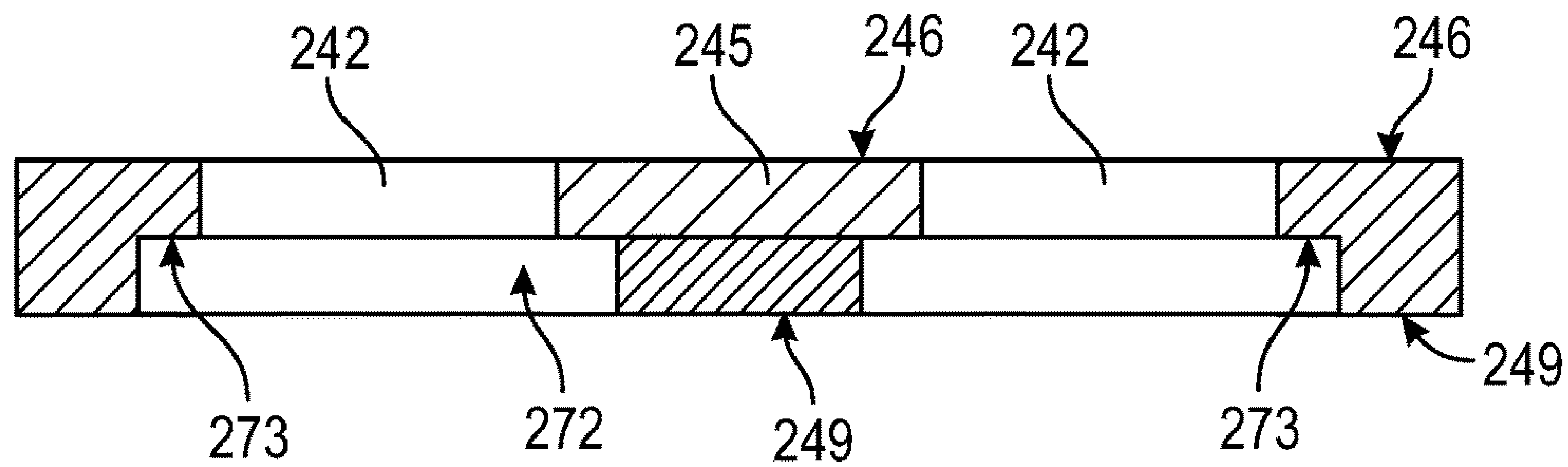

FIG. 12B

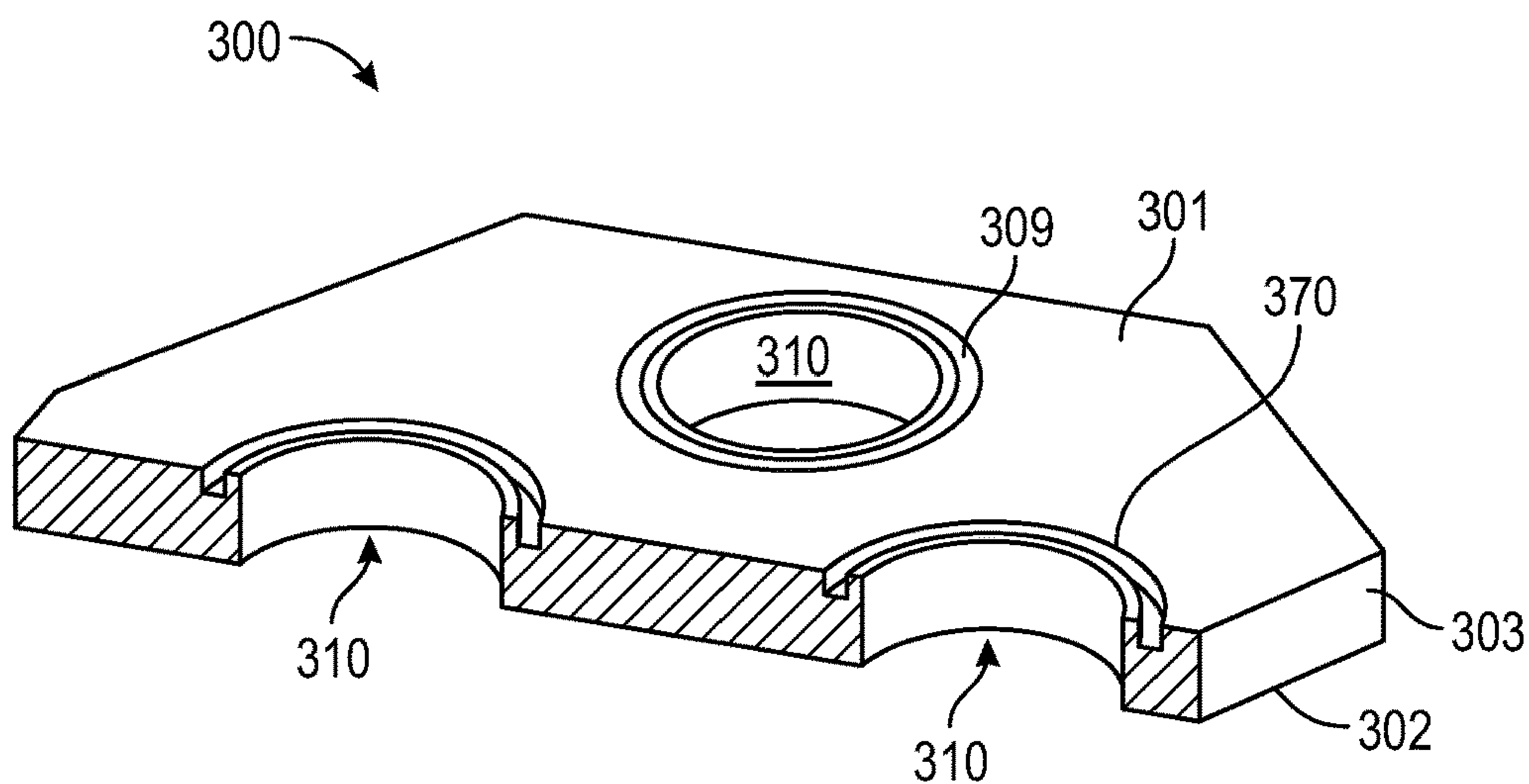

FIG. 13

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FIG. 14

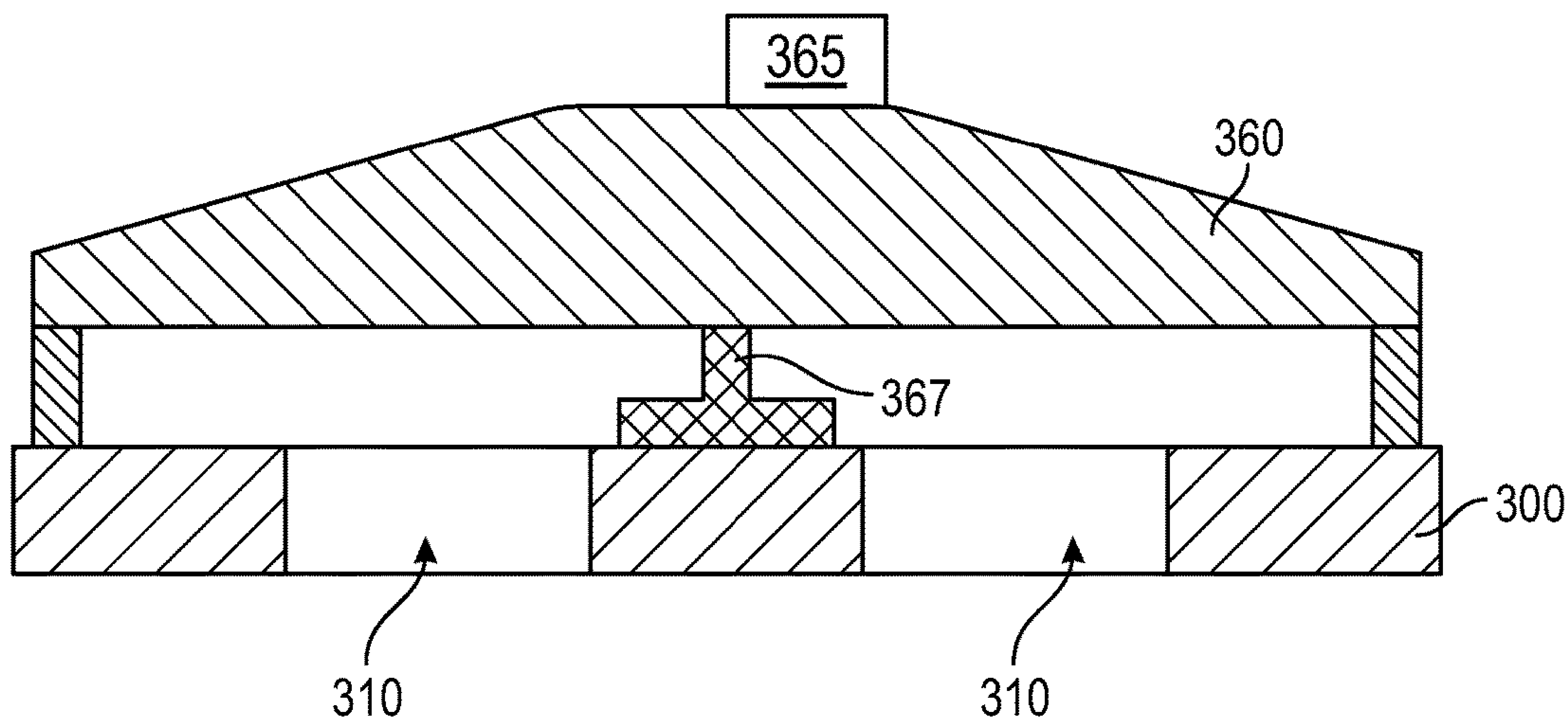

FIG. 15

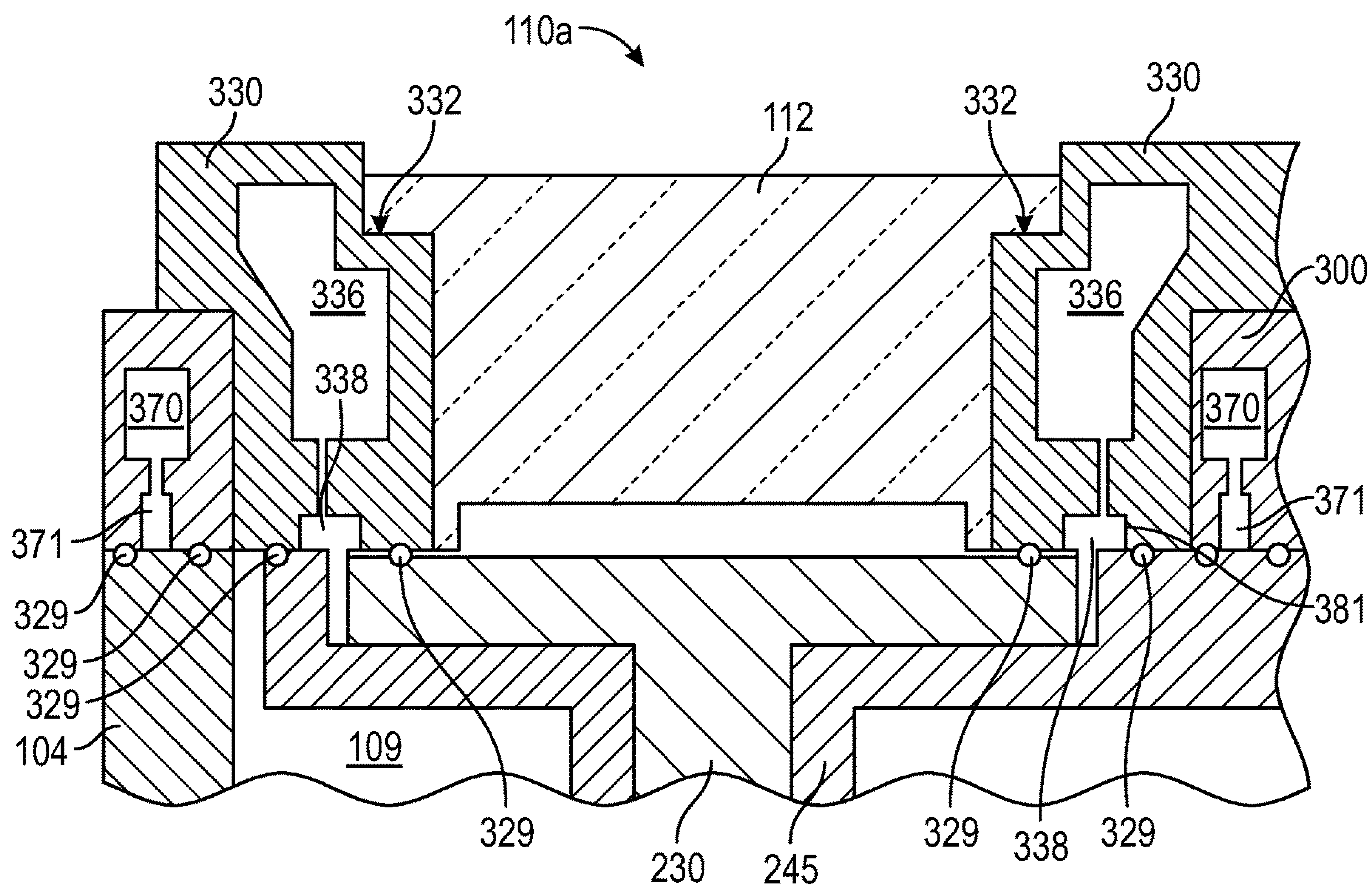

FIG. 16

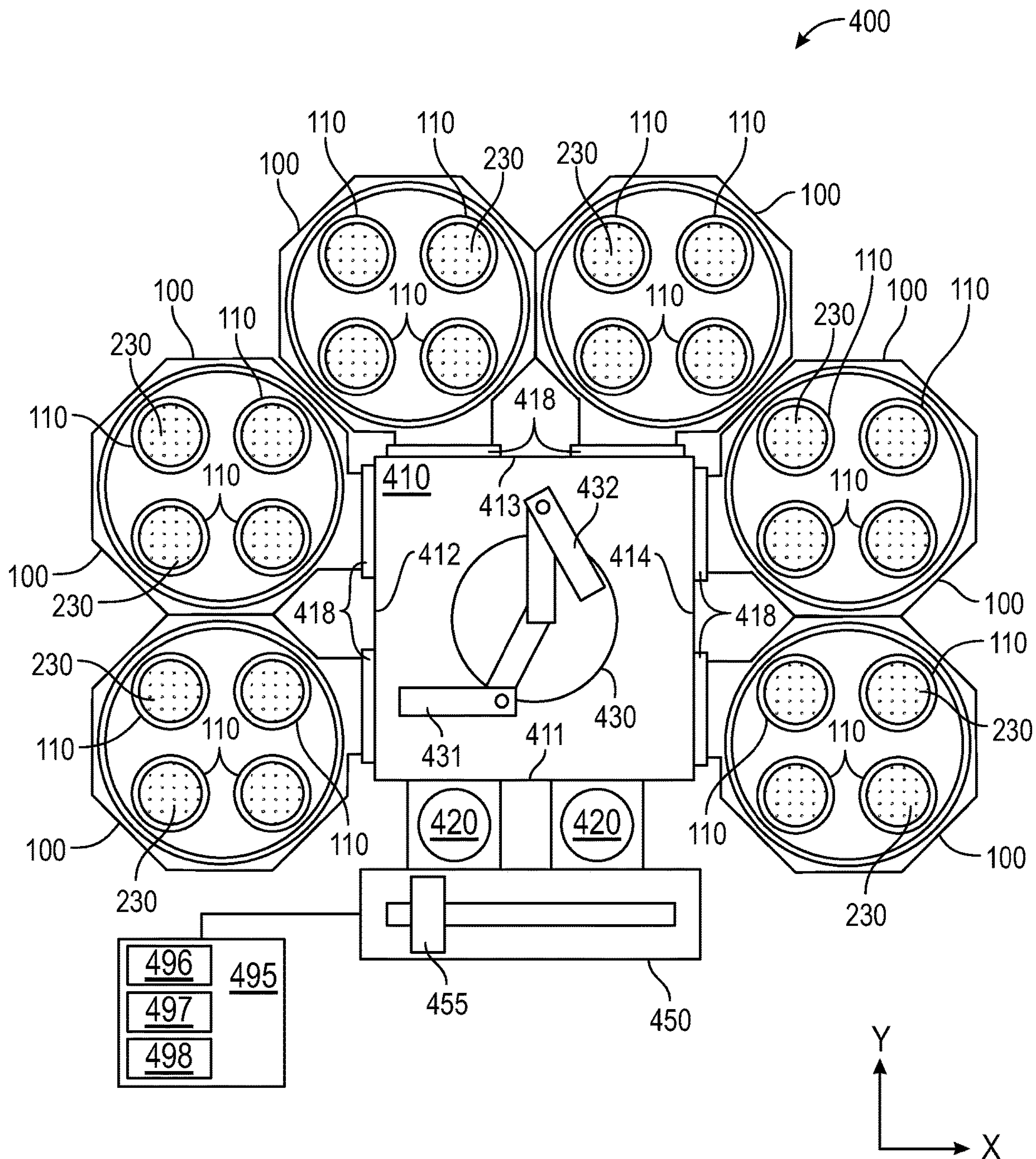

FIG. 17

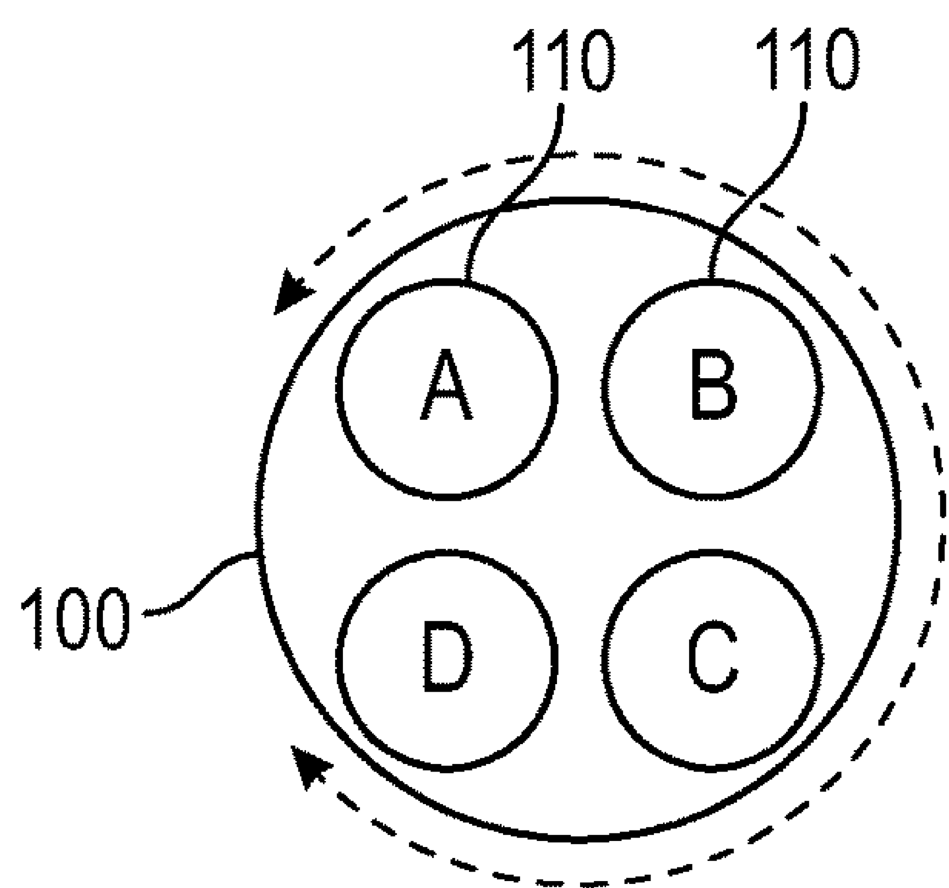

FIG. 18A

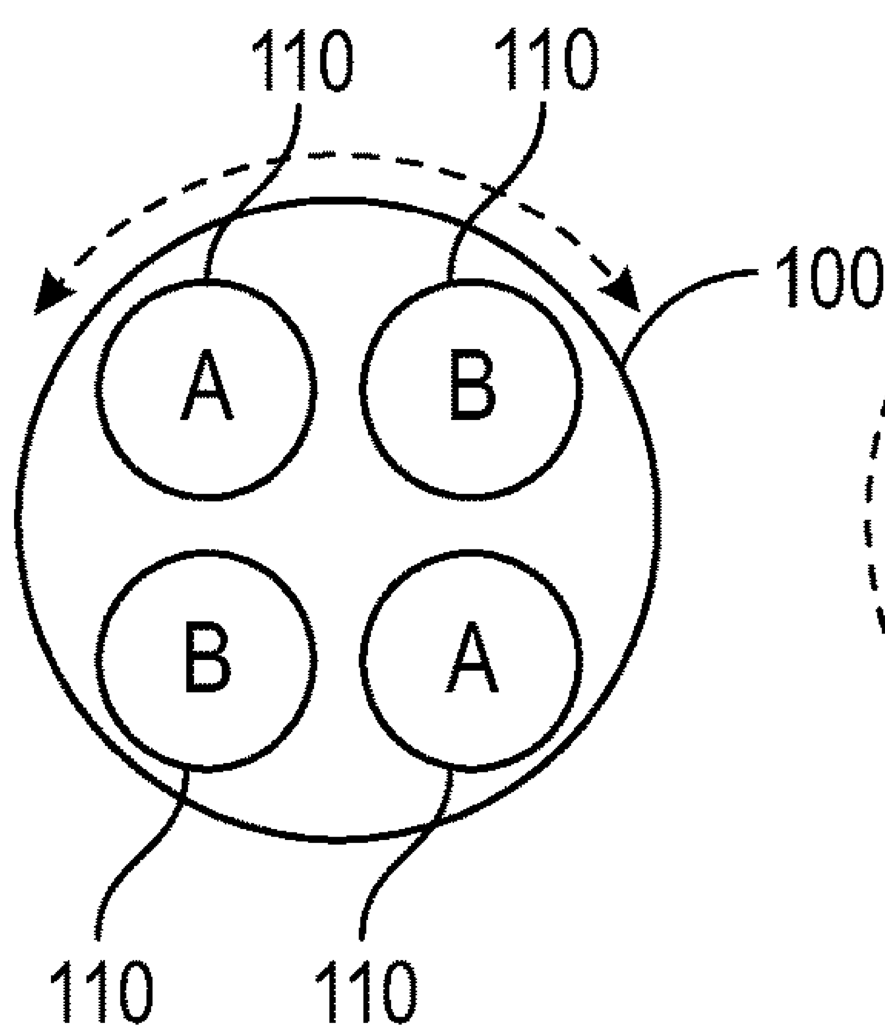

FIG. 18B

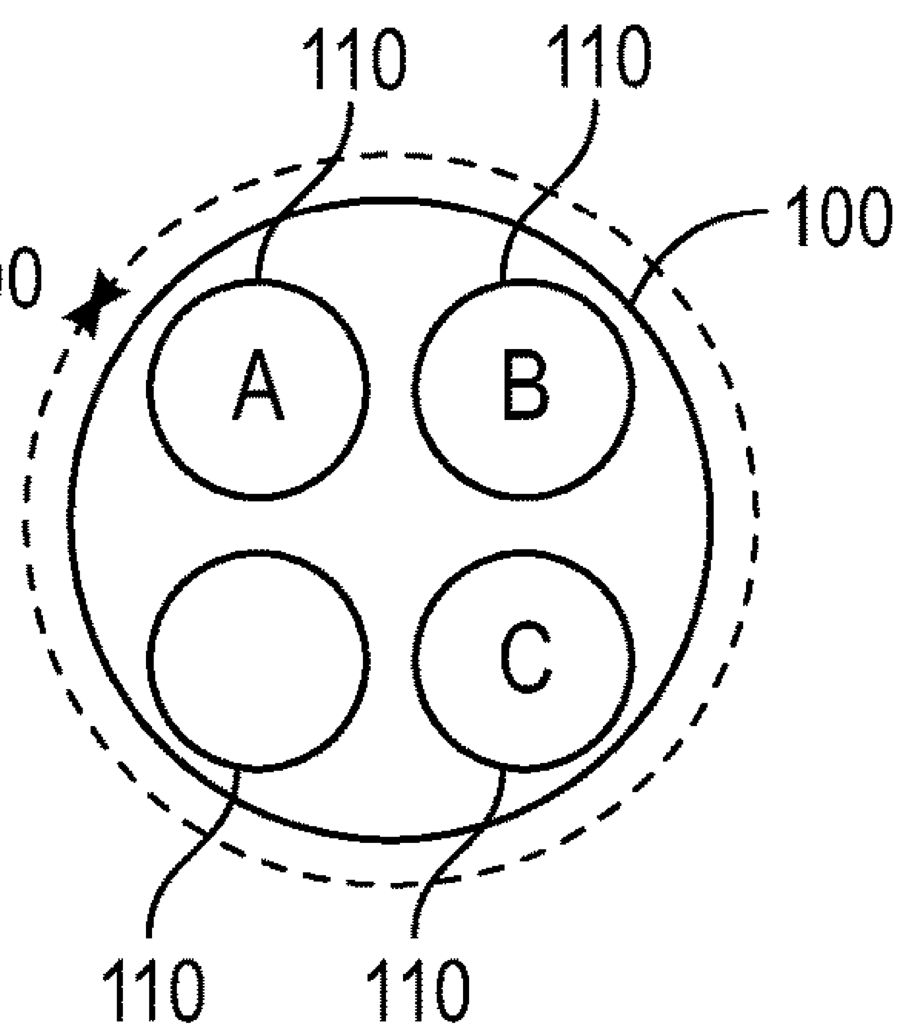

FIG. 18C

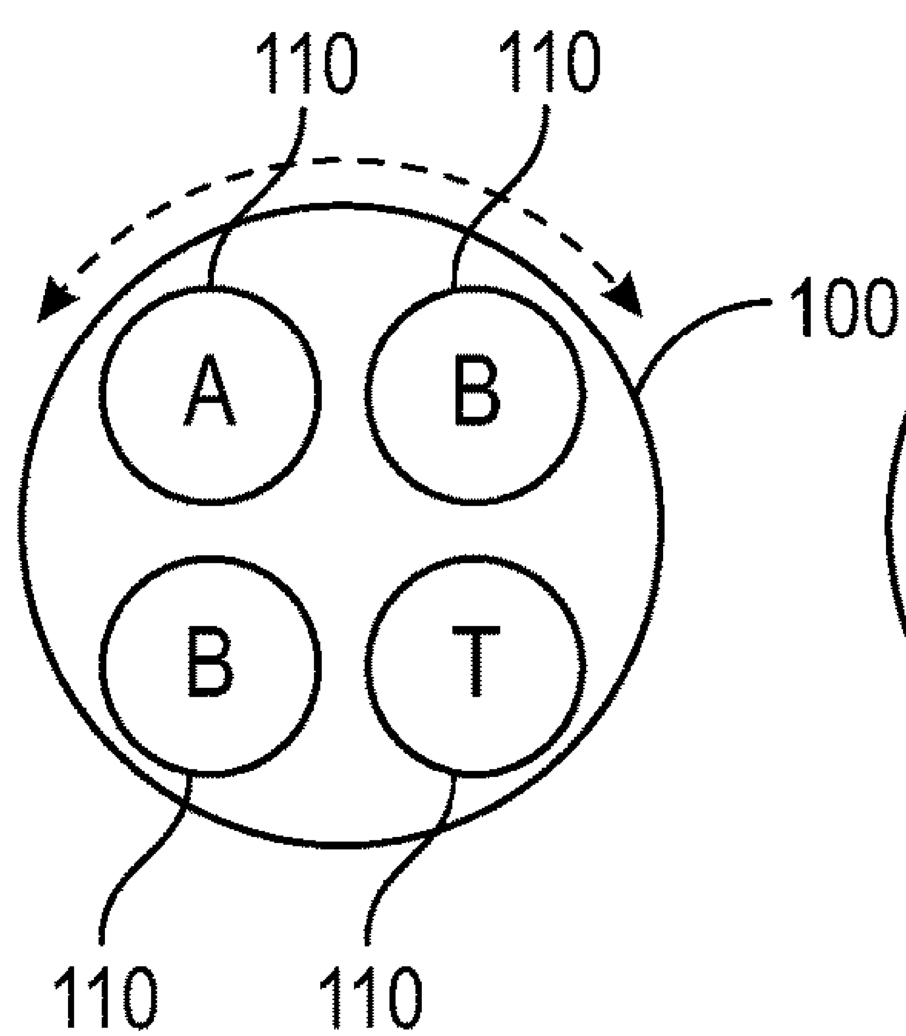

FIG. 18D

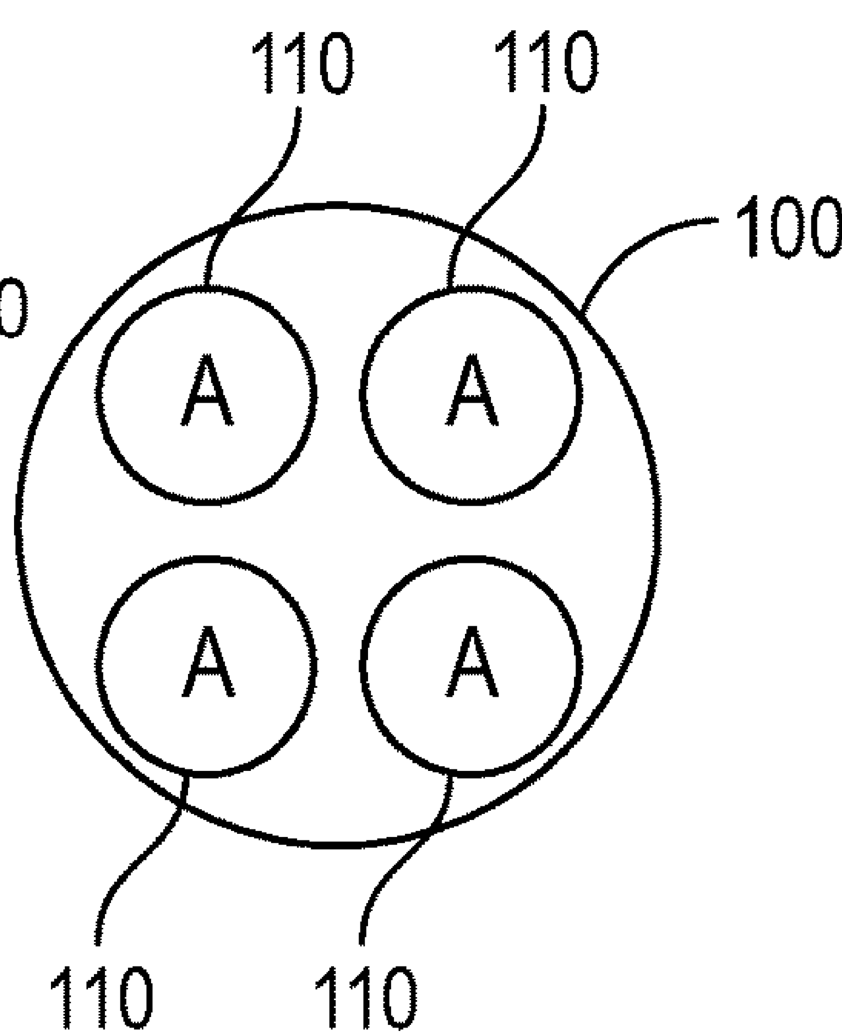

FIG. 18E

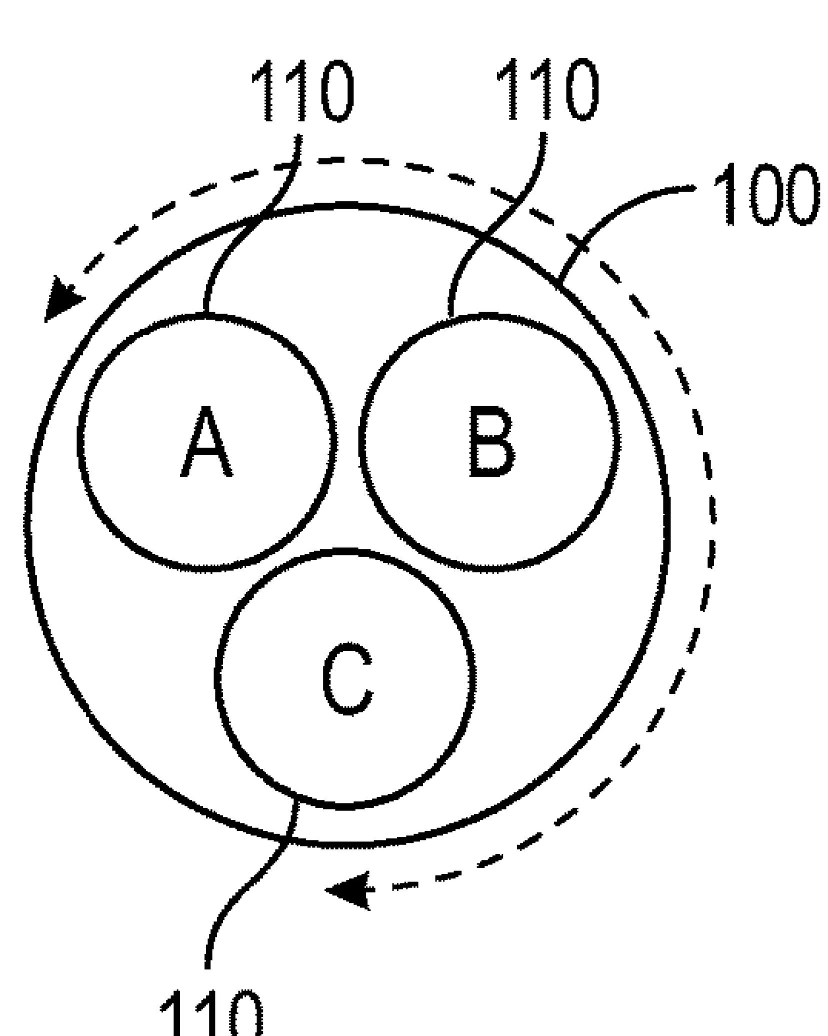

FIG. 18F

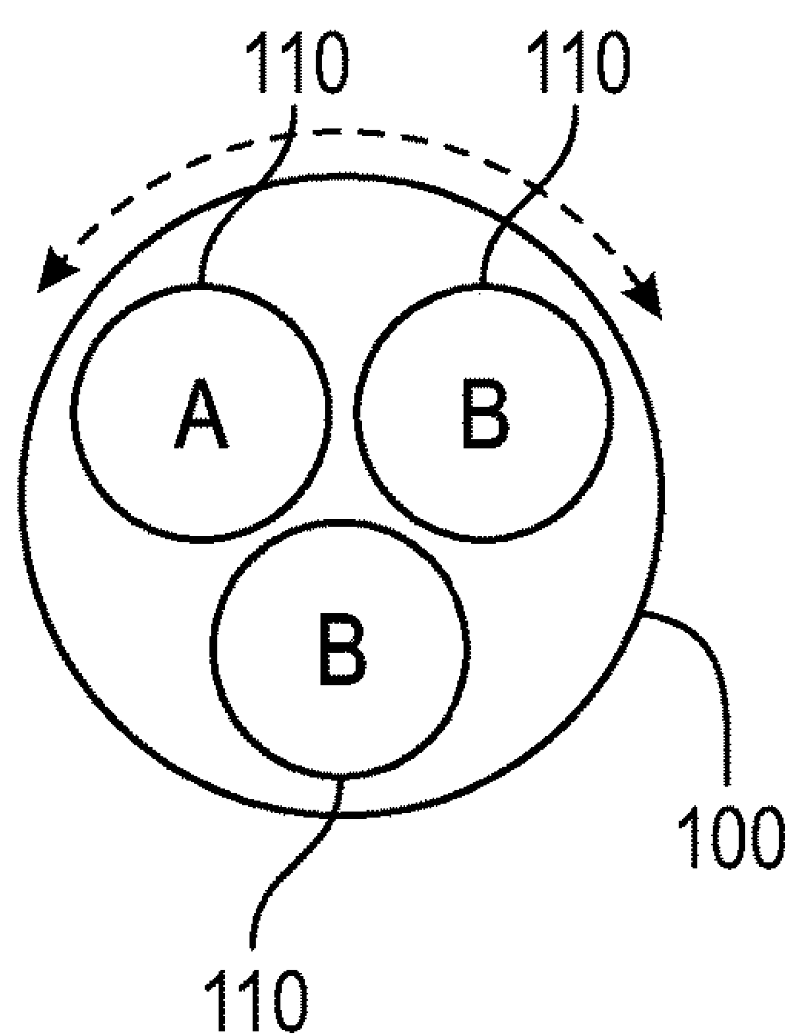

FIG. 18G

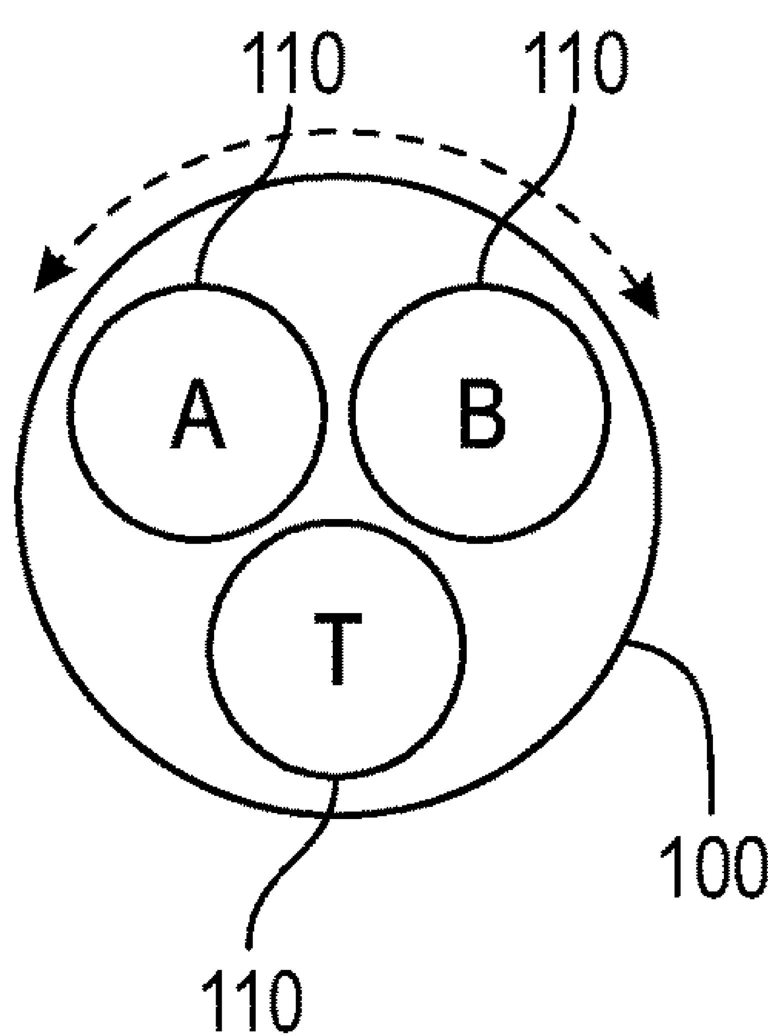

FIG. 18H

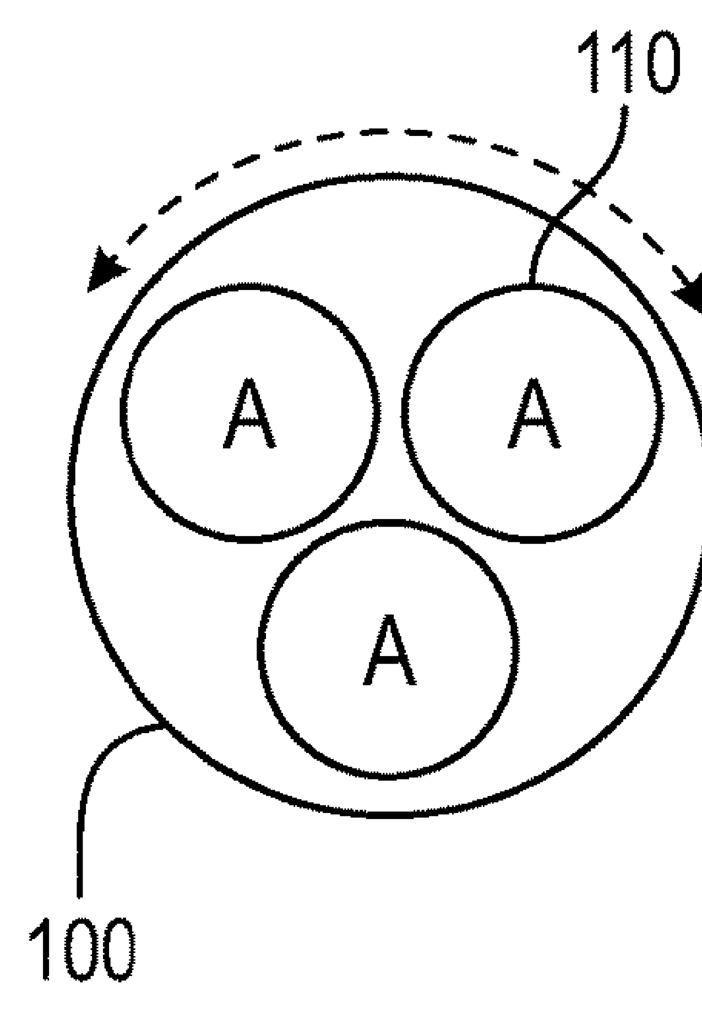

FIG. 18I

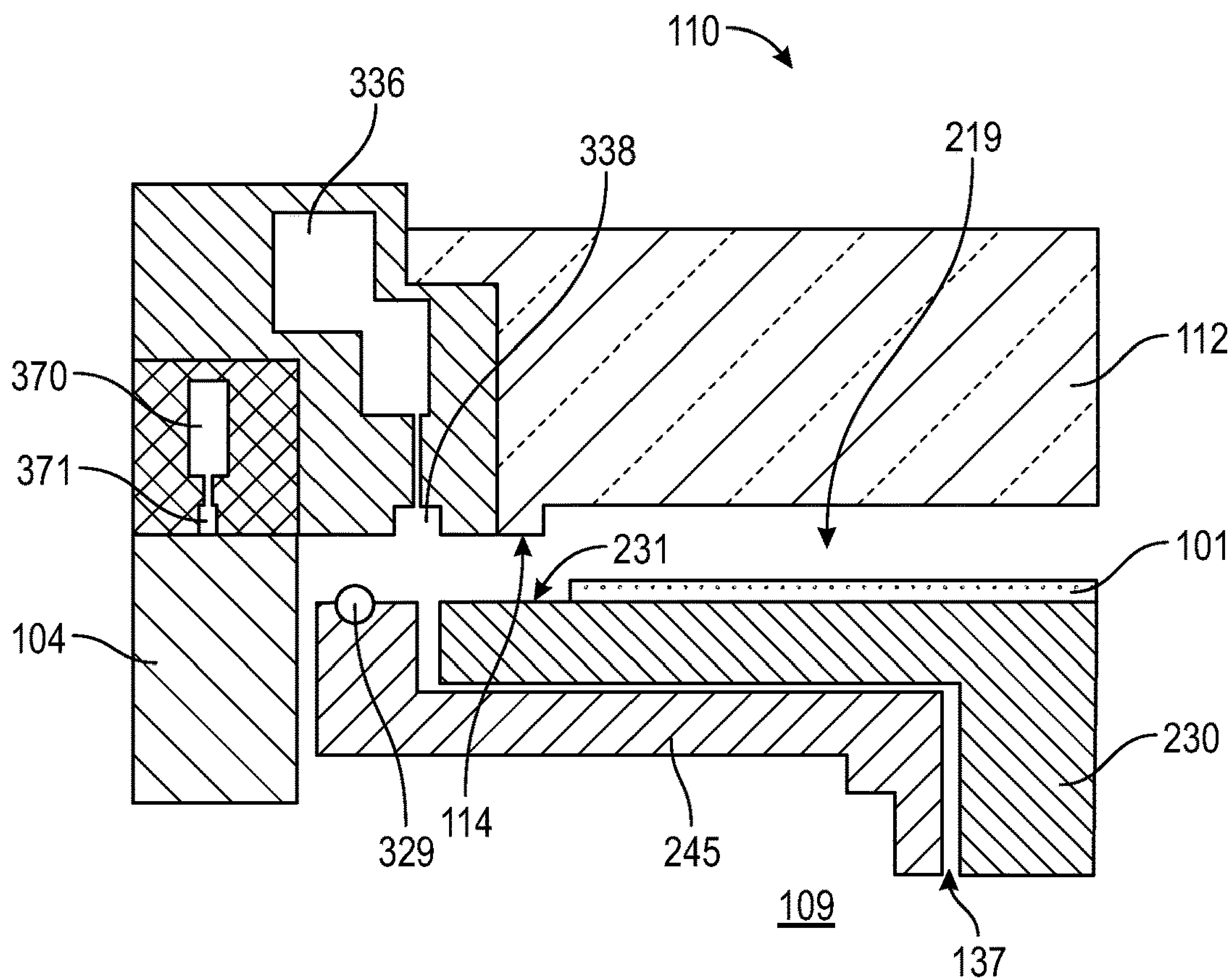

FIG. 19A

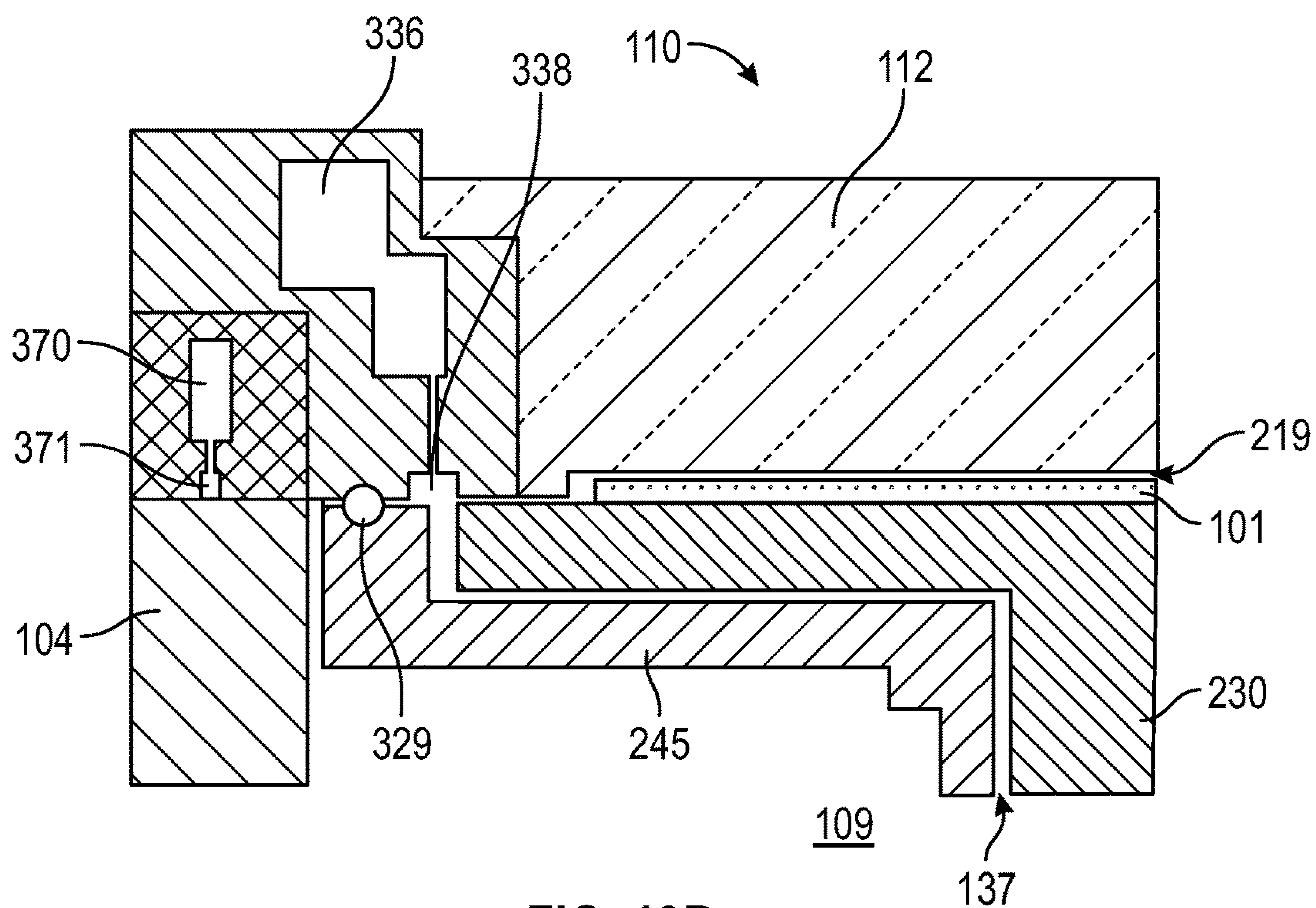

FIG. 19B

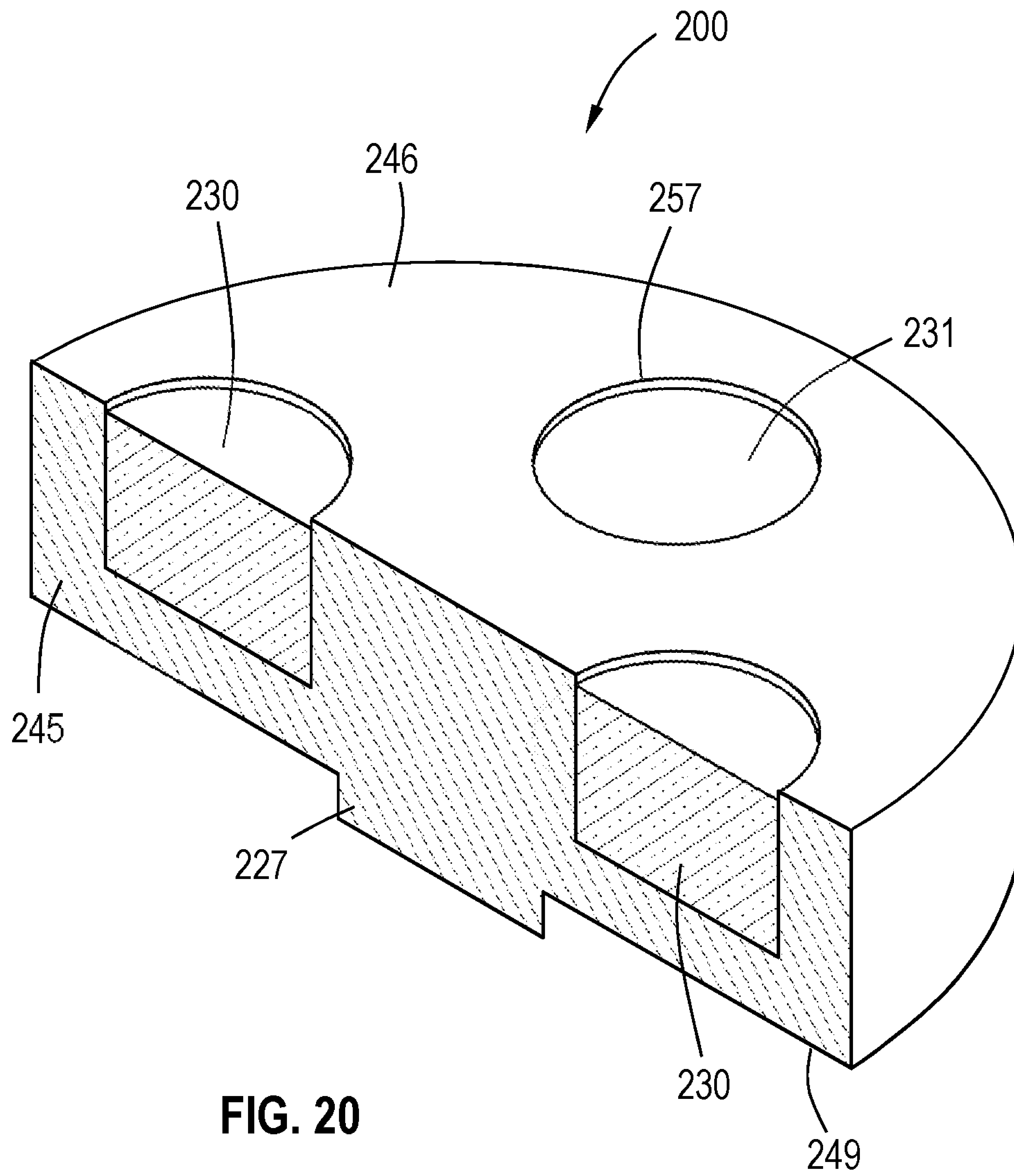

FIG. 20

SINGLE WAFER PROCESSING ENVIRONMENTS WITH SPATIAL SEPARATION

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to U.S. Provisional Application No. 62/578,365, filed Oct. 27, 2017, the entire disclosure of which is hereby incorporated by reference herein.

TECHNICAL FIELD

The present disclosure relates generally to apparatus for depositing thin films. In particular, the disclosure relates to apparatus having a plurality of movable heating wafer supports and spatially separated processing stations.

BACKGROUND

Current atomic layer deposition (ALD) processes have a number of potential issues and difficulties. Many ALD chemistries (e.g., precursors and reactants) are "incompatible", which means that the chemistries cannot be mixed together. If the incompatible chemistries mix, a chemical vapor deposition (CVD) process, instead of the ALD process could occur. The CVD process generally has less thickness control than the ALD process and/or can result in the creation of gas phase particles which can cause defects in the resultant device. For a traditional time-domain ALD process in which a single reactive gas is flowed into the processing chamber at a time, a long purge/pump out time occurs so that the chemistries are not mixed in the gas phase. A spatial ALD chamber can move one or more wafer(s) from one environment to a second environment faster than a time-domain ALD chamber can pump/purge, resulting in higher throughput.

The semiconductor industry requires high quality films which can be deposited at lower temperatures (e.g., below 350° C.). To deposit high quality films at temperatures below where the film would be deposited with a thermal only process, alternative energy sources are needed. Plasma solutions can be used to provide the additional energy in the form of ions and radicals to the ALD film. The challenge is to get sufficient energy on the vertical side wall ALD film. Ions typically are accelerated through a sheath above the wafer surface in a direction normal to the wafer surface. Therefore, the ions provide energy to horizontal ALD film surfaces, but provide an insufficient amount of energy to the vertical surfaces because the ions moving parallel to the vertical surfaces.

Some process chambers incorporate a capacitively coupled plasma (CCP). A CCP is created between a top electrode and the wafer, which is commonly known as CCP parallel plate plasma. A CCP parallel plate plasma generates very high ion energies across the two sheeths and, therefore, do a very poor job on the vertical side wall surfaces. By spacially moving a wafer to an environment optimized for creating high radical flux and ions flux with lower energies and wider angular distribution to the wafer surface, better vertical ALD film properties can be achieved. Such plasma sources include microwave, inductively coupled plasma (ICP), or higher frequency CCP solutions with 3rd electrodes (i.e., the plasma is created between two electrodes above the wafer and not using the wafer as a primary electrode).

Current spatial ALD processing chambers rotate a plurality of wafers on a heated circular platen at a constant speed which moves the wafers from one processing environment to an adjacent environment. The different processing environments create a separation of the incompatible gases. However, current spatial ALD processing chambers do not enable the plasma environment to be optimized for plasma exposure, resulting in non-uniformity, plasma damage and/or processing flexibility issues.

For example, the process gases flow across the wafer surface. Because the wafer is rotating about an offset axis, the leading edge and trailing edge of the wafer have different flow streamlines. Additionally, there is also a flow difference between the inner diameter edge and outer diameter edge of the wafer caused by the slower velocity at the inner edge and faster at the outer edge. These flow non-uniformities can be optimized but not eliminated. Plasma damage can be created when exposing a wafer to non-uniform plasma. The constant speed rotation of these spatial processing chambers require the wafers to move into and out of a plasma and therefore some of the wafer is exposed to plasma while other areas are outside of the plasma. Furthermore, it can be difficult to change the exposure times in a spatial processing chamber due to the constant rotation rate. As an example, a process uses a 0.5 sec exposure to gas A followed by a 1.5 sec plasma treatment. Because the tool runs at constant rotational velocity, the only way to do this is to make the plasma environment 3 times bigger than the gas A dosing environment. If another process is to be performed where the gas A and plasma times are equal, a change to the hardware would be needed. The current spatial ALD chambers can only slow down or speed up the rotation speed but cannot adjust for time differences between the steps without changing the chamber hardware for smaller or larger areas. Therefore, there is a need in the art for improved deposition apparatus and methods.

SUMMARY

One or more embodiments of the disclosure are directed to support assemblies comprising a rotatable center base, at least two support arms and heaters. The rotatable center base defines a rotation axis. Each of the support arms extend from the center base and have an inner end in contact with the center base and an outer end. Heaters having a support surface are positioned on the outer end of each of the support arms.

Additional embodiments of the disclosure are directed to processing chambers comprising a housing, a plurality of process stations and a support assembly. The housing has walls, a bottom and a top defining an interior volume. The plurality of process stations are in the interior volume of the housing. The process stations are positioned in a circular arrangement around a rotational axis. Each of the process stations comprises a gas injector having a front face. The front faces of each of the gas injectors are substantially coplanar. The support assembly is in the interior volume of the housing positioned below the plurality of process stations. The support assembly includes a rotatable center base with a plurality of support arms extending from the center base. Each support arm has an inner end in contact with the center base and an outer end. A heater having a support surface is positioned on the outer end of each of the support arms.

BRIEF DESCRIPTION OF THE DRAWINGS

So that the manner in which the above recited features of the present disclosure can be understood in detail, a more

particular description of the disclosure, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this disclosure and are therefore not to be considered limiting of its scope, for the disclosure may admit to other equally effective embodiments.

FIG. **1** shows an cross-sectional isometric view of a processing chamber in accordance with one or more embodiment of the disclosure;

FIG. **2** shows a cross-sectional view of a processing chamber in accordance with one or more embodiment of the disclosure;

FIG. **3** shows a bottom parallel projection view of a support assembly in accordance with one or more embodiment of the disclosure;

FIG. **4** shows a top parallel projection view of the support assembly in accordance with one or more embodiment of the disclosure;

FIG. **5** shows a top parallel projection view of a support assembly in accordance with one or more embodiment of the disclosure;

FIG. **6** shows a cross-sectional side view of a support assembly in accordance with one or more embodiment of the disclosure;

FIG. **7** shows a partial cross-sectional side view of a support assembly in accordance with one or more embodiment of the disclosure;

FIG. **8** shows a partial cross-sectional side view of a support assembly in accordance with one or more embodiment of the disclosure;

FIG. **9** is a partial cross-sectional side view of a support assembly in accordance with one or more embodiment of the disclosure;

FIG. **10**A is a top isometric view of a support plate in accordance with one or more embodiment of the disclosure;

FIG. **10**B is a cross-sectional side view of the support plate of FIG. **10**A taken along line **10**B-**10**B';

FIG. **11**A is a bottom isometric view of a support plate in accordance with one or more embodiment of the disclosure;

FIG. **11**B is a cross-sectional side view of the support plate of FIG. **11**A taken along line **11**B-**11**B';

FIG. **12**A is a bottom isometric view of a support plate in accordance with one or more embodiment of the disclosure;

FIG. **12**B is a cross-sectional side view of the support plate of FIG. **12**A taken along line **12**B-**12**B';

FIG. **13** is a cross-sectional isometric view of a top plate for a processing chamber in accordance with one or more embodiment of the disclosure;

FIG. **14** is an exploded cross-sectional view of a process station in accordance with one or more embodiment of the disclosure;

FIG. **15** is a schematic cross-sectional side view of a top plate for a processing chamber in accordance with one or more embodiment of the disclosure;

FIG. **16** is a partial cross-sectional side view of a process station in a processing chamber in accordance with one or more embodiment of the disclosure;

FIG. **17** is a schematic representation of a processing platform in accordance with one or more embodiment of the disclosure;

FIGS. **18**A through **18**I shows schematic views of process station configurations in a processing chamber in accordance with one or more embodiment of the disclosure;

FIGS. **19**A and **19**B show schematic representations of a process in accordance with one or more embodiment of the disclosure; and

FIG. **20** shows a cross-sectional schematic representation of a support assembly in accordance with one or more embodiment of the disclosure.

DETAILED DESCRIPTION

Before describing several exemplary embodiments of the disclosure, it is to be understood that the disclosure is not limited to the details of construction or process steps set forth in the following description. The disclosure is capable of other embodiments and of being practiced or being carried out in various ways.

A "substrate" as used herein, refers to any substrate or material surface formed on a substrate upon which film processing is performed during a fabrication process. For example, a substrate surface on which processing can be performed include materials such as silicon, silicon oxide, strained silicon, silicon on insulator (SOI), carbon doped silicon oxides, amorphous silicon, doped silicon, germanium, gallium arsenide, glass, sapphire, and any other materials such as metals, metal nitrides, metal alloys, and other conductive materials, depending on the application. Substrates include, without limitation, semiconductor wafers. Substrates may be exposed to a pretreatment process to polish, etch, reduce, oxidize, hydroxylate, anneal and/or bake the substrate surface. In addition to film processing directly on the surface of the substrate itself, in the present disclosure, any of the film processing steps disclosed may also be performed on an under-layer formed on the substrate as disclosed in more detail below, and the term "substrate surface" is intended to include such under-layer as the context indicates. Thus for example, where a film/layer or partial film/layer has been deposited onto a substrate surface, the exposed surface of the newly deposited film/layer becomes the substrate surface.

As used in this specification and the appended claims, the terms "precursor", "reactant", "reactive gas" and the like are used interchangeably to refer to any gaseous species that can react with the substrate surface, or with a film formed on the substrate surface.

One or more embodiments of the disclosure use spatial separation between two or more processing environments. Some embodiments advantageously provide apparatus and methods to maintain separation of incompatible gases. Some embodiments advantageously provide apparatus and methods including optimizable plasma processing. Some embodiments advantageously provide apparatus and methods that allow for a differentiated thermal dosing environment, a differentiated plasma treatment environment and other environments.

One or more embodiments of the disclosure are directed to processing chambers having four spatially separated processing environments, also referred to as processing stations. Some embodiments have more than four and some embodiments have less than four. The processing environments can be mounted coplanar to the wafer(s) that are moving in a horizontal plane. The process environments are placed in a circular arrangement. A rotatable structure with one to four (or more) individual wafer heaters mounted thereon moves the wafers in a circular path with a diameter similar to the process environments. Each heater may be temperature controlled and may have one or multiple concentric zones. For wafer loading, the rotatable structure could be lowered so that a vacuum robot could pick finished wafers and place unprocessed wafers on lift pins located above each wafer heater (in the lower Z position). In operation, each wafer can be under an independent environ-

ment until the process is finished, then rotatable structure can rotate to move the wafers on the heaters to the next environment (90° rotation for four stations, 120° rotation if three stations) for processing.

Some embodiments of the disclosure advantageously provide spatial separation for ALD with incompatible gases. Some embodiments allow for higher throughput and tool resource utilization than a traditional time-domain or spatial process chamber. Each process environment can operate at a different pressure. The heater rotation has Z direction motion so each heater can be sealed into a chamber.

Some embodiments advantageously provide plasma environments that can include one or more of microwave, ICP, parallel plate CCP or 3 electrode CCP. The entire wafer can be immersed in plasma; eliminating the plasma damage from non-uniform plasma across the wafer.

In some embodiments, a small gap between the showerhead and the wafer can be used to increase dose gas utilization and cycle time speed. Precise showerhead temperature control and high operating range (up to 230° C.). Without being bound by theory, it is believed that the closer the showerhead temperature is to the wafer temperature, the better the wafer temperature uniformity.

The showerheads can include small gas holes (<200 μm), a high number of gas holes (many thousands to greater than 10 million) and recursively fed gas distribution inside the showerhead using small distribution volume to increase speed. The small size and high number gas holes can be created by laser drilling or dry etching. When a wafer is close to the showerhead, there is turbulence experienced from the gas going through the vertical holes towards the wafer. Some embodiments allow for a slower velocity gas through the showerhead using a large number of holes spaced close together achieving a uniform distribution to the wafer surface.

Some embodiments are directed to integrated processing platforms using a plurality of spatially separated processing stations (chambers) on a single tool. The processing platform can have a variety of chambers that can perform different processes.

Some embodiments of the disclosure are directed to apparatus and methods to move wafer(s) attached to a wafer heater(s) from one environment to another environment. The rapid movement can be enabled by electrostatically chucking (or clamping) the wafer(s) to the heater(s). The movement of the wafers can be in linear or circular motion.

Some embodiments of the disclosure are directed to methods of processing one or more substrates. Examples include, but are not limited to, running one wafer on one heater to a plurality of different sequential environments spatially separated; running two wafers on two wafer heaters to three environments (two environments the same and one different environment between the two similar environments); wafer one sees environment A then B, and repeats, while wafer two sees B then A and repeats; one environment remaining idle (without wafer); running two wafers in two first environments and two second environments where both wafers see the same environments at the same time (i.e., both wafers in A then both go to B); four wafers with two A and two B environments; and two wafers processing in A's while the other two wafers are processing in B's. In some embodiments, wafers are exposed to environment A and environment B repeatedly, and then exposed to a third environment located in the same chamber.

In some embodiments, wafers go through a plurality of chambers for processing where at least one of the chambers does sequential processing with a plurality of spatially separated environments within the same chamber.

Some embodiments are directed to apparatus with spatially separated processing environments within the same chamber where the environments are at significantly different pressures (e.g., one at <100 mT another at >3T). In some embodiments, the heater rotation robot moves in the z-axis to seal each wafer/heater into the spatially separated environments.

Some embodiments include a structure built above the chamber with a vertical structural member applying a force upward to the center of the chamber lid to eliminate deflection caused by the pressure of atmosphere on the topside and the vacuum on the other side. The magnitude of force of the structure above can be mechanically adjusted based on the deflection of the top plate. The force adjustment can be done automatically using a feedback circuit and force transducer or manually using, for example, a screw that can be turned by an operator.

FIGS. **1** and **2** illustrate a processing chamber **100** in accordance with one or more embodiment of the disclosure. FIG. **1** shows the processing chamber **100** illustrated as a cross-sectional isometric view in accordance with one or more embodiment of the disclosure. FIG. **2** shows a processing chamber **100** in cross-section according to one or more embodiment of the disclosure. Accordingly, some embodiments of the disclosure are directed to processing chambers **100** that incorporate a support assembly **200** and top plate **300**.

The processing chamber **100** has a housing **102** with walls **104** and a bottom **106**. The housing **102** along with the top plate **300** define an interior volume **109**, also referred to as a processing volume.

The processing chamber **100** includes a plurality of process stations **110**. The process stations **110** are located in the interior volume **109** of the housing **102** and are positioned in a circular arrangement around the rotational axis **211** of the support assembly **200**. The process stations **110** are spatially arranged around the interior volume **109** of the processing chamber **100**. Each process station **110** comprises a gas injector **112** having a front face **114**. In some embodiments, the front faces **114** of each of the gas injectors **112** are substantially coplanar. The process stations **110** are defined as a region in which processing can occur. For example, a process station **110** can be defined by the support surface **231** of the heaters **230**, as described below, and the front face **114** of the gas injectors **112**.

The process stations **110** can be configured to perform any suitable process and provide any suitable process conditions. The type of gas injector **112** used will depend on, for example, the type of process being performed and the type of showerhead or gas injector. For example, a process station **110** configured to operate as an atomic layer deposition apparatus may have a showerhead or vortex type gas injector. Whereas, a process station **110** configured to operate as a plasma station may have one or more electrode and/or grounded plate configuration to generate a plasma while allowing a plasma gas to flow toward the wafer. The embodiment illustrated in FIG. **2** has a different type of process station **110** on the left side (process station **110***a*) of the drawing than on the right side (process station **110***b*) of the drawing. Suitable process stations **110** include, but are not limited to, thermal processing stations, microwave plasma, three-electrode CCP, ICP, parallel plate CCP, UV exposure, laser processing, pumping chambers, annealing stations and metrology stations.

FIGS. **3** through **6** illustrate support assemblies **200** in accordance with one or more embodiments of the disclosure. The support assembly **200** includes a rotatable center base **210**. The rotatable center base **210** can have a symmetrical or asymmetrical shape and defines a rotational axis **211**. The rotational axis **211**, as can be seen in FIG. **6**, extends in a first direction. The first direction may be referred to as the vertical direction or along the z-axis; however, it will be understood that the use of the term "vertical" in this manner is not limited to a direction parallel to the pull of gravity.

The support assembly **200** includes at least two support arms **220** connected to and extending from the center base **210**. The support arms **220** have an inner end **221** and an outer end **222**. The inner end **221** is in contact with the center base **210** so that when the center base **210** rotates around the rotational axis **211**, the support arms **220** rotate as well. The support arms **220** can be connected to the center base **210** at the inner end **221** by fasteners (e.g., bolts) or by being integrally formed with the center base **210**.

In some embodiments, the support arms **220** extend orthogonal to the rotational axis **211** so that one of the inner ends **221** or outer ends **222** are further from the rotational axis **211** than the other of the inner ends **221** and outer ends **222** on the same support arm **220**. In some embodiments, the inner end **221** of the support arm **220** is closer to the rotational axis **211** than the outer end **222** of the same support arm **220**.

The number of support arms **220** in the support assembly **200** can vary. In some embodiments, there are at least two support arms **220**, at least three support arms **220**, at least four support arms **220**, or at least five support arms **220**. In some embodiments, there are three support arms **220**. In some embodiments, there are four support arms **220**. In some embodiments, there are five support arms **220**. In some embodiments, there are six support arms **220**.

The support arms **220** can be arranged symmetrically around the center base **210**. For example, in a support assembly **200** with four support arms **220**, each of the support arms **220** are positioned at 90° intervals around the center base **210**. In a support assembly **200** with three support arms **220**, the support arms **220** are positioned at 120° intervals around the center base **210**. Stated differently, in embodiments with four support arms **220**, the support arms are arrange to provide four-fold symmetry around the rotation axis **211**. In some embodiments, the support assembly **200** has n-number of support arms **220** and the n-number of support arms **220** are arranged to provide n-fold symmetry around the rotation axis **211**.

A heater **230** is positioned at the outer end **222** of the support arms **220**. In some embodiments, each support arm **220** has a heater **230**. The center of the heaters **230** are located at a distance from the rotational axis **211** so that upon rotation of the center base **210** the heaters **230** move in a circular path.

The heaters **230** have a support surface **231** which can support a wafer. In some embodiments, the heater **230** support surfaces **231** are substantially coplanar. As used in this manner, "substantially coplanar" means that the planes formed by the individual support surfaces **231** are within ±5°, ±4°, ±3°, ±2° or ±1° of the planes formed by the other support surfaces **231**.

In some embodiments, the heaters **230** are positioned directly on the outer end **222** of the support arms **220**. In some embodiments, as illustrated in the drawings, the heaters **230** are elevated above the outer end **222** of the support arms **220** by a heater standoff **234**. The heater standoffs **234** can be any size and length to increase the height of the heaters **230**.

In some embodiments, a channel **236** is formed in one or more of the center base **210**, the support arms **220** and/or the heater standoffs **234**. The channel **236** can be used to route electrical connections or to provide a gas flow.

The heaters can be any suitable type of heater known to the skilled artisan. In some embodiments, the heater is a resistive heater with one or more heating elements within a heater body.

The heaters **230** of some embodiments include additional components. For example, the heaters may comprise an electrostatic chuck. The electrostatic chuck can include various wires and electrodes so that a wafer positioned on the heater support surface **231** can be held in place while the heater is moved. This allows a wafer to be chucked onto a heater at the beginning of a process and remain in that same position on that same heater while moving to different process regions. In some embodiments, the wires and electrodes are routed through the channels **236** in the support arms **220**. FIG. **7** shows an expanded view of a portion of a support assembly **200** in which the channel **236** is shown. The channel **236** extends along the support arm **220** and the heater standoff **234**. A first electrode **251***a* and second electrode **251***b* are in electrical communication with heater **230**, or with a component inside heater **230** (e.g., a resistive wire). First wire **253***a* connects to first electrode **251***a* at first connector **252***a*. Second wire **253***b* connects to second electrode **251***b* at second connector **252***b*.

In some embodiments, a temperature measuring device (e.g., pyrometer, thermistor, thermocouple) is positioned within the channel **236** to measure one or more of the heater **230** temperature or the temperature of a substrate on the heater **230**. In some embodiments, the control and/or measurement wires for the temperature measurement device are routed through the channel **236**. In some embodiments, one or more temperature measurement devices are positioned within the processing chamber **100** to measure the temperature of the heaters **230** and/or a wafer on the heaters **230**. Suitable temperature measurement devices are known to the skilled artisan and include, but are not limited to, optical pyrometers and contact thermocouples.

The wires can be routed through the support arms **220** and the support assembly **200** to connect with a power source (not shown). In some embodiments, the connection to the power source allows continuous rotation of the support assembly **200** without tangling or breaking the wires **253***a*, **253***b*. In some embodiments, as shown in FIG. **7**, the first wire **253***a* and second wire **253***b* extend along the channel **236** of the support arm **220** to the center base **210**. In the center base **210** the first wire **253***a* connects with center first connector **254***a* and the second wire **253***b* connects with center second connector **254***b*. The center connectors **254***a*, **254***b* can be part of a connection plate **258** so that power or electronic signals can pass through center connectors **254***a*, **254***b*. In the illustrated embodiment, the support assembly **200** can rotate continuously without twisting or breaking wires because the wires terminate in the center base **210**. A second connection is on the opposite side of the connection plate **258** (outside of the processing chamber).

In some embodiments, the wires are connected directly to a power source or electrical component outside of the processing chamber through the channel **236**. In embodiments of this sort, the wires have sufficient slack to allow the support assembly **200** to be rotated a limited amount without twisting or breaking the wires. In some embodiments, the

support assembly **200** is rotated less than or equal to about 1080°, 990°, 720°, 630°, 360° or 270° before the direction of rotation is reversed. This allows the heaters to be rotated through each of the stations without breaking the wires.

Referring again to FIGS. **3** through **6**, the heater **230** and support surface **231** can include one or more gas outlets to provide a flow of backside gas. This may assist in the removal of the wafer from the support surface **231**. As shown in FIGS. **4** and **5**, the support surface **231** includes a plurality of openings **237** and a gas channel **238**. The openings **237** and/or gas channel **238** can be in fluid communication with one or more of a vacuum source or a gas source (e.g., a purge gas). In embodiments of this sort, a hollow tube can be included to allow fluid communication of a gas source with the openings **237** and/or gas channel **238**.

In some embodiments, the heater **230** and/or support surface **231** are configured as an electrostatic chuck. In embodiments of this sort, the electrodes **251***a*, **251***b* (see FIG. **7**) can include control lines for the electrostatic chuck.

Some embodiments of the support assembly **200** include a sealing platform **240**. The sealing platform has a top surface **241**, a bottom surface and a thickness. The sealing platform **240** can be positioned around the heaters **230** to help provide a seal or barrier to minimize gas flowing to a region below the support assembly **200**.

In some embodiments, as shown in FIG. **4**, the sealing platforms **240** are ring shaped and are positioned around each heater **230**. In the illustrated embodiment, the sealing platforms **240** are located below the heater **230** so that the top surface **241** of the sealing platform **240** is below the support surface **231** of the heater.

The sealing platforms **240** can have a number of purposes. For example, the sealing platforms **240** can be used to increase the temperature uniformity of the heater **230** by increasing thermal mass. In some embodiments, the sealing platforms **240** are integrally formed with the heater **230** (see for example FIG. **6**). In some embodiments, the sealing platforms **240** are separate from the heater **230**. For example, the embodiment illustrated in FIG. **8** has the sealing platform **240** as a separate component connected to the heater standoff **234** so that the top surface **241** of the sealing platform **240** is below the level of the support surface **231** of the heater **230**.

In some embodiments, the sealing platforms **240** act as a holder for a support plate **245**. In some embodiments, as shown in FIG. **5**, the support plate **245** is a single component that surrounds all of the heaters **230** with a plurality of openings **242** to allow access to the support surface **231** of the heaters **230**. The openings **242** can allow the heaters **230** to pass through the support plate **245**. In some embodiments, the support plate **245** is fixed so that the support plate **245** moves vertically and rotates with the heaters **230**.

In one or more embodiments, the support assembly **200** is a drum shaped component; for example, as shown in FIG. **20**, a cylindrical body with a top surface **246** configured to support a plurality of wafers. The top surface **246** of the support assembly **200** an have a plurality of recesses (pockets **257**) sized to support one or more wafers during processing. In some embodiments, the pockets **257** have a depth equal to about the thickness of the wafers to be processed so that the top surface of the wafers are substantially coplanar with the top surface **246** of the cylindrical body. An example of such a support assembly **200** can be envisioned as a modification of FIG. **5** without the support arms **220**. FIG. **20** illustrates a cross-sectional view of an embodiment of the support assembly **200** using a cylindrical body. The support assembly **200** includes a plurality of pockets **257** sized to support a wafer for processing. In the illustrated embodiment, the bottom of the pockets **257** is the support surface **231** of a heater **230**. The power connections for the heaters **230** can be routed through the support post **227** and the support plate **245**. The heaters **230** can be independently powered to control the temperature of the individual pockets **257** and wafers.

Referring to FIG. **9**, in some embodiments, the support plate **245** has a top surface **246** forming a major plane **248** that is substantially parallel with a major plane **247** formed by the support surface **231** of the heater **230**. In some embodiments, the support plate **245** has a top surface **246** forming a major plane **248** that is a distance D above the major plane **247** of the support surface **231**. In some embodiments, the distance D is substantially equal to the thickness of a wafer **260** to be processed so that the wafer **260** surface **261** is coplanar with the top surface **246** of the support plate **245**, as shown in FIG. **6**. As used in this manner, the term "substantially coplanar" means that the major plane formed by the surface **261** of the wafer **260** is within ±1 mm, ±0.5 mm, ±0.4 mm, ±0.3 mm, ±0.2 mm or ±0.1 mm of coplanarity.

Referring to FIG. **9**, some embodiments of the disclosure have separate components making up the support surfaces for processing. Here, the sealing platform **240** is a separate component than the heater **230** and is positioned so that the top surface **241** of the sealing platform **240** is below the support surface **231** of the heater **230**. The distance between the top surface **241** of the sealing platform **240** and the support surface **231** of the heater **230** is sufficient to allow support plate **245** to be positioned on the sealing platforms **240**. The thickness of the support plate **245** and/or position of the sealing platform **240** can be controlled so that the distance D between the top surface **246** of the support plate **245** is sufficient so that the top surface **261** of a wafer **260** (see FIG. **6**) is substantially coplanar with the top surface **246** of the support plate **245**.

In some embodiments, as shown in FIG. **9**, the support plate **245** is supported by support post **227**. The support post **227** may have utility in preventing sagging of the center of the support plate **245** when a single component platform is used. In some embodiments, there are no sealing platforms **240** and the support post **227** is the primary support for the support plate **245**

The support plates **245** can have a variety of configurations to interact with various configurations of heaters **230** and sealing platforms **240**. FIG. **10**A shows a top isometric view of a support plate **245** in accordance with one or more embodiment of the disclosure. FIG. **10**B shows a cross-sectional view of the support plate **245** of FIG. **10**A taken along line **10**B-**10**B'. In this embodiment, the support plate **245** is a planar component in which the top surface **246** and bottom surface **249** are substantially flat and/or substantially coplanar. The illustrated embodiment may be particularly useful where a sealing platform **240** is used to support the support plate **245**, as shown in FIG. **9**.

FIG. **11**A shows a bottom isometric view of another embodiment of a support plate **245** in accordance with one or more embodiment of the disclosure. FIG. **11**B shows a cross-sectional view of the support plate **245** of FIG. **11**A taken along line **11**B-**11**B'. In this embodiment, each of the openings **242** has a protruding ring **270** around the outer periphery of the opening **242** on the bottom surface **249** of the support plate **245**.

FIG. **12**A shows a bottom isometric view of another embodiment of a support plate **245** in accordance with one or more embodiment of the disclosure. FIG. **12**B shows a

cross-sectional view of the support plate **245** of FIG. **12**A taken along line **12**B-**12**B'. In this embodiment, each of the openings **242** has a recessed ring **272** in the bottom surface **249** of the support plate **245** around the outer periphery of the opening **242**. The recessed ring **272** creates a recessed bottom surface **273**. Embodiment of this sort may be useful where sealing platforms **240** are either not present or are coplanar with the support surface **231** of the heaters **230**. The recessed bottom surface **273** can be positioned on the support surface **231** of the heater **230** so that the bottom portion of the support plate **245** extends below the support surface **231** of the heater **230** around the sides of the heater **230**.

Some embodiments of the disclosure are directed to top plates **300** for multi-station processing chambers. Referring to FIGS. **1** and **13**, the top plate **300** has a top surface **301** and a bottom surface **302** defining a thickness of the lid, and one or more edges **303**. The top plate **300** includes at least one opening **310** extending through the thickness thereof. The openings **310** are sized to permit the addition of a gas injector **112** which can form a process station **110**.

FIG. **14** illustrates an exploded view of a processing station **110** in accordance with one or more embodiment of the disclosure. The processing station **110** illustrated comprises three main components: the top plate **300** (also called a lid), a pump/purge insert **330** and a gas injector **112**. The gas injector **112** shown in FIG. **14** is a showerhead type gas injector. In some embodiments, the insert is connected to or in fluid communication with a vacuum (exhaust). In some embodiments, the insert is connected to or in fluid communication with a purge gas source.

The openings **310** in the top plate **300** can be uniformly sized or have different sizes. Different sized/shape gas injectors **112** can be used with a pump/purge insert **330** that is suitably shaped to transition from the opening **310** to the gas injector **112**. For example, as illustrated, the pump/purge insert **330** includes a top **331** and bottom **333** with a sidewall **335**. When inserted into the opening **310** in the top plate **300**, a ledge **334** adjacent the bottom **333** can be positioned on the shelf **315** formed in the opening **310**. In some embodiments, there is no shelf **315** in the opening and a flange portion **337** of the pump/purge insert **330** rests on top of the top plate **300**. In the illustrated embodiment, the ledge **334** rests on shelf **315** with an o-ring **314** positioned between to help form a gas-tight seal.

In some embodiments, there are one or more purge rings **309** (see FIG. **13**) in the top plate **300**. The purge rings **309** can be in fluid communication with a purge gas plenum (not shown) or a purge gas source (not shown) to provide a positive flow of purge gas to prevent leakage of processing gases from the processing chamber.

The pump/purge insert **330** of some embodiments includes a gas plenum **336** with at least one opening **338** in the bottom **333** of the pump/purge insert **330**. The gas plenum **336** has an inlet (not shown), typically near the top **331** or sidewall **335** of the pump/purge insert **330**.

In some embodiments, the plenum **336** can be charged with a purge or inert gas which can pass through the opening **338** in the bottom **333** of the pump/purge insert **330**. The gas flow through the opening **338** can help create a gas curtain type barrier to prevent leakage of process gases from the interior of the processing chamber.

In some embodiments, the plenum **336** is connected to or in fluid communication with a vacuum source. In such an embodiment, gases flow through the opening **338** in the bottom **333** of the pump/purge insert **330** into the plenum **336**. The gases can be evacuated from the plenum to exhaust. Such arrange can be used to evacuate gases from the process station **110** during use.

The pump/purge insert **330** includes an opening **339** in which a gas injector **112** can be inserted. The gas injector **112** illustrated has a flange **342** which can be in contact with the ledge **332** adjacent the top **331** of the pump/purge insert **330**. The diameter or width of the gas injector **112** can be any suitable size that can fit within the opening **339** of the pump/purge insert **330**. This allows gas injectors **112** of various types to be used within the same opening **310** in the top plate **300**.

With reference to FIGS. **2** and **15**, some embodiments of the top plate **300** include a bar **360** that passes over a center portion of the top plate **300**. The bar **360** can be connected to the top plate **300** near the center using connector **367**. The connector **367** can be used to apply force orthogonal to the top **331** or bottom **333** of the top plate **300** to compensate for bowing in the top plate **300** as a result of pressure differentials or due to the weight of the top plate **300**. In some embodiments, the bar **360** and connector **367** are capable of compensating for deflection of up to or equal to about 1.5 mm at the center of a top plate having a width of about 1.5 m and a thickness of up to or equal to about 100 mm. In some embodiments, a motor **365** or actuator is connected to connector **367** and can cause a change in directional force applied to the top plate **300**. The motor **365** or actuator can be supported on the bar **360**. The bar **360** illustrated is in contact with the edges of the top plate **300** at two locations. However, the skilled artisan will recognize that there can be one connection location or more than two connection locations.

In some embodiments, as illustrated in FIG. **2**, the support assembly **200** includes at least one motor **250**. The at least one motor **250** is connected to the center base **210** and is configured to rotate the support assembly **200** around the rotational axis **211**. In some embodiments, the at least one motor is configured to move the center base **210** in a direction along the rotational axis **211**. For example, in FIG. **2**, motor **255** is connected to motor **250** and can move the support assembly **200** along the rotational axis **211**. Stated differently, the motor **255** illustrated can move the support assembly **200** along the z-axis, vertically or orthogonally to the movement caused by motor **250**. In some embodiments, as illustrated, there is a first motor **250** to rotate the support assembly **200** around the rotational axis **211** and a second motor **255** to move the support assembly **200** along the rotational axis **211** (i.e., along the z-axis or vertically).

Referring to FIGS. **2** and **16**, one or more vacuum streams and/or purge gas streams can be used to help isolate one process station **110***a* from an adjacent process station **110***b*. A purge gas plenum **370** can be in fluid communication with a purge gas port **371** at the outer boundary of the process stations **110**. In the embodiment illustrated in FIG. **16**, the purge gas plenum **370** and purge gas port **371** are located in the top plate **300**. Plenum **336**, shown as part of the pump/purge insert **330**, is in fluid communication with opening **338** which acts as a pump/purge gas port. The purge gas port **371** and purge gas plenum **370**, as shown in FIG. **13**, and the vacuum port (opening **338**) can extend around the perimeter of the process station **110** to form a gas curtain. The gas curtain can help minimize or eliminate leakage of process gases into the interior volume **109** of the processing chamber.

In the embodiment illustrated in FIG. **16**, differential pumping can be used to help isolate the process station **110**. The pump/purge insert **330** is shown in contact with the heater **230** and support plate **245** with o-rings **329**. The

o-rings **329** are positioned on either side of the opening **338** in fluid communication with the plenum **336**. One o-ring **329** is positioned within the circumference of the opening **338** and the other o-ring **329** is position outside the circumference of the opening **338**. The combination of o-rings **329** and pump/purge plenum **336** with opening **338** can provide sufficient differential pressure to maintain gas-tight sealing of the process station **110** from the interior volume **109** of the processing chamber **100**. In some embodiments, there is one o-ring **329** positioned either inside or outside of the circumference of the opening **338**. In some embodiments, there are two o-rings **329** positioned—one inside and one outside of—the circumference of the purge gas port **371** in fluid communication with plenum **370**. In some embodiments, there is one o-ring **329** positioned either inside or outside of the circumference of purge gas port **371** in fluid communication with plenum **370**.

The boundary of a process station **110** can be considered the region within which a process gas is isolated by the pump/purge insert **330**. In some embodiments, the outer boundary of the process station **110** is the outermost edge **381** of the opening **338** in fluid communication with the plenum **336** of the pump/purge insert **330**, as shown in FIGS. **14** and **16**.

The number of process stations **110** can vary with the number of heaters **230** and support arms **220**. In some embodiments, there are an equal number of heaters **230**, support arms **220** and process stations **110**. In some embodiments, the heaters **230**, support arms **220** and process stations **110** are configured to that each of the support surfaces **231** of the heaters **230** can be located adjacent the front faces **214** of different process stations **110** at the same time. Stated differently, each of the heaters is positioned in a process station at the same time.

The spacing of the processing stations **110** around the processing chamber **100** can be varied. In some embodiments, the processing stations **110** are close enough together to minimize space between the stations so that a substrate can be moved rapidly between the process stations **110** while spending a minimum amount of time and transfer distance outside of one of the stations. In some embodiments, the process stations **110** are positioned close enough that a wafer being transported on the support surface **231** of a heater **230** is always within one of the process stations **110**.

FIG. **17** shows a processing platform **400** in accordance with one or more embodiment of the disclosure. The embodiment shown in FIG. **17** is merely representative of one possible configuration and should not be taken as limiting the scope of the disclosure. For example, in some embodiments, the processing platform **400** has a different numbers of one or more of the processing chambers **100**, buffer stations **420** and/or robot **430** configurations than the illustrated embodiment.

The exemplary processing platform **400** includes a central transfer station **410** which has a plurality of sides **411**, **412**, **413**, **414**. The transfer station **410** shown has a first side **411**, a second side **412**, a third side **413** and a fourth side **414**. Although four sides are shown, those skilled in the art will understand that there can be any suitable number of sides to the transfer station **410** depending on, for example, the overall configuration of the processing platform **400**. In some embodiments, there the transfer station **410** has three sides, four sides, five sides, six sides, seven sides or eight sides.

The transfer station **410** has a robot **430** positioned therein. The robot **430** can be any suitable robot capable of moving a wafer during processing. In some embodiments, the robot **430** has a first arm **431** and a second arm **432**. The first arm **431** and second arm **432** can be moved independently of the other arm. The first arm **431** and second arm **432** can move in the x-y plane and/or along the z-axis. In some embodiments, the robot **430** includes a third arm (not shown) or a fourth arm (not shown). Each of the arms can move independently of other arms.

The embodiment illustrated includes six processing chambers **100** with two connected to each of the second side **412**, third side **413** and fourth side **414** of the central transfer station **410**. Each of the processing chambers **100** can be configured to perform different processes.

The processing platform **400** can also include one or more buffer station **420** connected to the first side **411** of the central transfer station **410**. The buffer stations **420** can perform the same or different functions. For example, the buffer stations may hold a cassette of wafers which are processed and returned to the original cassette, or one of the buffer stations may hold unprocessed wafers which are moved to the other buffer station after processing. In some embodiments, one or more of the buffer stations are configured to pre-treat, pre-heat or clean the wafers before and/or after processing.

The processing platform **400** may also include one or more slit valves **418** between the central transfer station **410** and any of the processing chambers **100**. The slit valves **418** can open and close to isolate the interior volume within the processing chamber **100** from the environment within the central transfer station **410**. For example, if the processing chamber will generate plasma during processing, it may be helpful to close the slit valve for that processing chamber to prevent stray plasma from damaging the robot in the transfer station.

The processing platform **400** can be connected to a factory interface **450** to allow wafers or cassettes of wafers to be loaded into the processing platform **400**. A robot **455** within the factory interface **450** can be used to move the wafers or cassettes into and out of the buffer stations. The wafers or cassettes can be moved within the processing platform **400** by the robot **430** in the central transfer station **410**. In some embodiments, the factory interface **450** is a transfer station of another cluster tool (i.e., another multiple chamber processing platform).

A controller **495** may be provided and coupled to various components of the processing platform **400** to control the operation thereof. The controller **495** can be a single controller that controls the entire processing platform **400**, or multiple controllers that control individual portions of the processing platform **400**. For example, the processing platform **400** may include separate controllers for each of the individual processing chambers **100**, central transfer station **410**, factory interface **450** and robots **430**.

In some embodiments, the controller **495** includes a central processing unit (CPU) **496**, a memory **497**, and support circuits **498**. The controller **495** may control the processing platform **400** directly, or via computers (or controllers) associated with particular process chamber and/or support system components.

The controller **495** may be one of any form of general-purpose computer processor that can be used in an industrial setting for controlling various chambers and sub-processors. The memory **497** or computer readable medium of the controller **495** may be one or more of readily available memory such as random access memory (RAM), read only memory (ROM), floppy disk, hard disk, optical storage media (e.g., compact disc or digital video disc), flash drive, or any other form of digital storage, local or remote. The

memory **497** can retain an instruction set that is operable by the processor (CPU **496**) to control parameters and components of the processing platform **400**.

The support circuits **498** are coupled to the CPU **496** for supporting the processor in a conventional manner. These circuits include cache, power supplies, clock circuits, input/output circuitry and subsystems, and the like. One or more processes may be stored in the memory **498** as software routine that, when executed or invoked by the processor, causes the processor to control the operation of the processing platform **400** or individual processing chambers in the manner described herein. The software routine may also be stored and/or executed by a second CPU (not shown) that is remotely located from the hardware being controlled by the CPU **496**.

Some or all of the processes and methods of the present disclosure may also be performed in hardware. As such, the process may be implemented in software and executed using a computer system, in hardware as, e.g., an application specific integrated circuit or other type of hardware implementation, or as a combination of software and hardware. The software routine, when executed by the processor, transforms the general purpose computer into a specific purpose computer (controller) that controls the chamber operation such that the processes are performed.

In some embodiments, the controller **495** has one or more configurations to execute individual processes or sub-processes to perform the method. The controller **495** can be connected to and configured to operate intermediate components to perform the functions of the methods. For example, the controller **495** can be connected to and configured to control one or more of gas valves, actuators, motors, slit valves, vacuum control or other components.

FIGS. **18**A through **18**I illustrate various configurations of processing chambers **100** with different process stations **110**. The lettered circles represent the different process stations **110** and process conditions. For example, in FIG. **18**A, there are four process stations **110** each with a different letter. This represents four process stations **110** with each station having different conditions than the other stations. As indicated by the arrow, a process could occur by moving the heaters with wafers from stations A through D. After exposure to D, the cycle can continue or reverse.

In FIG. **18**B, two or four wafers can be processed at the same time with the wafers being moved on the heaters back and forth between the A and B positions. Two wafers could start in the A positions and two wafers in the B positions. The independent process stations **110** allow for the two of the stations to be turned off during the first cycle so that each wafer starts with an A exposure. The heaters and wafers can be rotated continuously either clockwise or counter-clockwise. In some embodiments, the heaters and wafers are rotated 90° in a first direction (e.g., A to B) and then 90° in a second direction (e.g., B back to A). This rotation can be repeated to result in four wafers/heaters being processed without rotating the support assembly by more than about 90°.

The embodiment illustrated in FIG. **18**B might also be useful in processing two wafers in the four process stations **110**. This might be particularly useful if one of the processes is at a very different pressure or the A and B process times are very different.

In FIG. **18**C, three wafers might be processed in a single processing chamber **100** in and ABC process. One station can either be turned off or perform a different function (e.g., pre-heating).

In FIG. **18**D, two wafers can be processed in an AB-Treat process. For example, wafers might be placed on the B heaters only. A quarter turn clockwise will place one wafer in the A station and the second wafer in the T station. Turning back will move both wafers to the B stations and another quarter turn counter-clockwise will place the second wafer in the A station and the first wafer in the B station.

In FIG. **18**E, up to four wafers can be processed at the same time. For example, if the A station is configured to perform a CVD or ALD process, four wafers can be processed simultaneously.

FIGS. **18**F through **18**I show similar types of configurations for a processing chamber **100** with three process stations **110**. Briefly, in FIG. **18**F, a single wafer (or more than one) can be subjected to an ABC process. In FIG. **18**G, two wafers can be subjected to an AB process by placing one in the A position and the other in one of the B positions. The wafers can then be moved back and forth so that the wafer starting in the B position moves to the A position in the first move and then back to the same B position. In FIG. **18**H a wafer can be subjected to an AB-Treat process. In FIG. **18**I, three wafers can be processed at the same time.

FIGS. **19**A and **19**B illustrate another embodiment of the disclosure. FIG. **19**A shows a partial view of a heater **230** and support plate **245** which has been rotated to a position beneath process station **110** so that wafer **101** is adjacent the gas injector **112**. An O-ring **329** on the support plate **245**, or on an outer portion of the heater **230**, is in a relaxed state.

FIG. **19**B shows the support plate **245** and heater **230** after being moved toward the process station **110** so that the support surface **231** of the heater **230** is in contact with or nearly contacts the front face **114** of the gas injector **112** in the process station **110**. In this position, O-ring **329** is compressed forming a seal around the outer edge of the support plate **245** or outer portion of the heater **230**. This allows the wafer **101** to be moved as close the gas injector **112** as possible to minimize the volume of the reaction region **219** so that the reaction region **219** can be rapidly purged.

Gases which might flow out of the reaction region **219** are evacuated through opening **338** into plenum **336** and to an exhaust or foreline (not shown). A purge gas curtain outside of the opening **338** can be generated by purge gas plenum **370** and purge gas port **371**. Additionally, a gap **137** between the heater **230** and the support plate **245** can help to further curtain off the reaction region **219** and prevent reactive gases from flowing into the interior volume **109** of the processing chamber **100**.

Referring back to FIG. **17**, the controller **495** of some embodiments has one or more configurations selected from: a configuration to move a substrate on the robot between the plurality of processing chambers; a configuration to load and/or unload substrates from the system; a configuration to open/close slit valves; a configuration to provide power to one or more of the heaters; a configuration to measure the temperature of the heaters; a configuration to measure the temperature of the wafers on the heaters; a configuration to load or unload wafers from the heaters; a configuration to provide feedback between temperature measurement and heater power control; a configuration to rotate the support assembly around the rotational axis; a configuration to move the support assembly along the rotational axis (i.e., along the z-axis); a configuration to set or change the rotation speed of the support assembly; a configuration to provide a flow of gas to a gas injector; a configuration to provide power to one or more electrodes to generate a plasma in a gas injector; a configuration to control a power supply for a plasma source;

a configuration to control the frequency and/or power of the plasma source power supply; and/or a configuration to provide control for a thermal anneal treatment station.

Reference throughout this specification to "one embodiment," "certain embodiments," "one or more embodiments" or "an embodiment" means that a particular feature, structure, material, or characteristic described in connection with the embodiment is included in at least one embodiment of the disclosure. Thus, the appearances of the phrases such as "in one or more embodiments," "in certain embodiments," "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily referring to the same embodiment of the disclosure. Furthermore, the particular features, structures, materials, or characteristics may be combined in any suitable manner in one or more embodiments.

Although the disclosure herein has been described with reference to particular embodiments, it is to be understood that these embodiments are merely illustrative of the principles and applications of the present disclosure. It will be apparent to those skilled in the art that various modifications and variations can be made to the method and apparatus of the present disclosure without departing from the spirit and scope of the disclosure. Thus, it is intended that the present disclosure include modifications and variations that are within the scope of the appended claims and their equivalents.

What is claimed is:

1. A support assembly comprising:
- a rotatable center base defining a rotational axis;
- at least two support arms extending from the rotatable center base, each of the support arms having an inner end in contact with the center base and an outer end further from the rotational axis than the inner end;
- a plurality of heaters, each heater positioned on the outer end of each of the support arms, each of the plurality of heaters having a support surface with a center located a distance from the rotational axis so that upon rotation of the center base the heaters move in a circular path; and
- a channel formed in the rotatable center base and the support arms, the channel configured to route electrical connections to the plurality of heaters;
- wherein the support surfaces of the heaters are substantially coplanar.

2. The support assembly of claim **1**, wherein the support arms extend orthogonal to the rotational axis.

3. The support assembly of claim **1**, wherein there are three support arms and three heaters.

4. The support assembly of claim **1**, wherein there are four support arms and four heaters.

5. The support assembly of claim **1**, wherein the heaters comprise an electrostatic chuck.

6. The support assembly of claim **1**, further comprising at least one motor connected to the center base, the at least one motor configured to rotate the support assembly around the rotational axis.

7. The support assembly of claim **6**, wherein the at least one motor is configured to move the center base in a direction along the rotational axis.

8. The support assembly of claim **1**, further comprising at least one sealing platform around the plurality of heaters, at least one sealing platform having a top surface forming a major plane that is substantially parallel with a major plane formed by the support surface of the plurality of heater.

9. The support assembly of claim **8**, wherein there is a plurality of sealing platforms and each of the plurality of heaters has a sealing platform positioned around the heater, each of the sealing platforms forming a ring shaped top surface.

10. The support assembly of claim **8**, further comprising a support plate having a plurality of openings, each of the plurality of openings surrounding a support surface of one of the plurality of heaters.

11. A support assembly comprising:
- a rotatable center base defining a rotational axis;
- at least two support arms extending from the center base orthogonal to the rotational axis, each of the support arms having an inner end in contact with the center base and an outer end;
- a heater positioned on the outer end of each of the support arms, each of the heaters having a support surface configured to support a substrate during processing and each of the support surfaces are substantially coplanar, the heaters comprising an electrostatic chuck, each heater having a ring shaped sealing platform positioned around the heater, the sealing platforms having a top surface forming a plane that is substantially parallel with a plane formed by the support surface of the heaters;
- a channel formed in the rotatable center base and the support arms, the channel configured to route electrical connections to the plurality of heaters;
- a first motor connected to the rotatable center base to rotate the rotatable center base, support arms and heaters around the rotational axis; and
- a second motor connected to the rotatable center base to move the rotatable center base, support arms and heaters in a direction along the rotational axis.

12. A processing chamber comprising:
- a housing having walls, a bottom and a top defining an interior volume;
- a plurality of process stations in the interior volume of the housing, the process stations positioned in a circular arrangement around a rotational axis, each process station comprising a gas injector having a front face, the front face of each of the gas injectors being substantially coplanar; and
- a support assembly in the interior volume of the housing, the support assembly positioned below the plurality of process stations, the support assembly including a rotatable center base with a plurality of support arms extending from the center base, each support arm having an inner end in contact with the center base and an outer end, a heater is positioned on the outer end of each of the support arms so that upon rotation of the center base the heaters move in a circular path, the heaters having a support surface configured to support a substrate during processing, and a channel is formed in the rotatable center base and the support arms, the channel configured to route electrical connections to the heater;
- wherein the support surfaces of the heaters are substantially coplanar.

13. The processing chamber of claim **12**, wherein the support arms extend orthogonal to the rotational axis.

14. The processing chamber of claim **12**, wherein there are an equal number of heaters, support arms and process stations configured so that each of the support surfaces of the heaters can be located adjacent the front face of a different process station at the same time.

15. The processing chamber of claim **12**, wherein the heaters comprise an electrostatic chuck.

16. The processing chamber of claim **12**, further comprising at least one motor connected to the center base, the at least one motor configured to rotate the support assembly around the rotational axis.

17. The processing chamber of claim **12**, wherein each heater further comprises a sealing platform positioned around the heater, the sealing platform having a top surface forming a major plane that is substantially parallel with a major plane formed by the support surface of the heater.

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